Ecological Risk Assessment

for

Des Moines TCE Site
Operable Unit 04

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LIST OF ABBREVIATIONS

ADD Average Daily Dose
AE Assessment Endpoint
AUF Area Use Factor
BAF Bioaccumulation Factor
BCF Bioconcentration Factor
BW Body Weight
COPC Contaminants of Potential Concern
ESB Equilibrium Sediment Benchmark
ESL Ecological Screening Level
EPC Exposure Point Concentration
ERA Ecological Risk Assessment
FCM Food Chain Multiplier
HQ Hazard Quotient
IR Ingestion Rate
LOAEL Lowest Observed Adverse Effect Level
log K_{ow} Octanol-Water Partitioning Coefficient
NOAEL No Observed Adverse Effect Level
OU Operable Unit
PCB Polychlorinated Biphenyls
PEC Probable Effect Concentration
POP Persistent Organic Pollutant
RI Remedial Investigation
SPA South Pond Area

1.0. INTRODUCTION

This Ecological Risk Assessment is being conducted as part of the fifth Five-Year Review for the Des Moines TCE Site. The ERA will be conducted according to the Ecological Risk Assessment Guidance for Superfund (USEPA, 1997), which includes the following eight steps:

1. Screening level problem formulation and effects evaluation;
2. Screening level exposure and risk evaluation;
3. Baseline risk assessment problem formulation;
4. Study design and data quality objectives;
5. Field verification of sampling design;
6. Site investigation;
7. Risk characterization;
8. Risk management.

The objective of this ERA, in particular, is to characterize potential ecological risk to the aquatic and terrestrial ecosystems associated with Operable Unit 04 (South Pond Area) of the Des Moines TCE Site.

2.0. SITE BACKGROUND

The Des Moines TCE Site is located in the south-central portion of the city of Des Moines, Iowa, adjacent to the Raccoon River. The Site includes a portion of the Des Moines Water Works facility; the Dico, Inc. property; the industrial area north of the Dico property; the Tuttle Street Landfill east of the Dico property; and the Frank DePuydt Woods south of the Dico property. In all, the Site encompasses more than 200 acres (Figure 1).

The Dico property has historically been used for a variety of industrial uses, including grey iron production; steel wheel manufacturing; and chemical and pesticide formulation and distribution. From the mid-1950s through the early 1970s, pesticide and herbicide formulation was conducted in Buildings 1 through 5 and the Maintenance Building. The primary formulation activities were conducted in Buildings 2 and 3, while Buildings 4 and 5 were primarily used for chemical and product storage. Operable unit two was initially designated to address chlorinated volatile organic compound impacted source soils and included all soils on the Dico property. Soil contamination was detected in the saturated zone approximately 30 feet below ground surface. However, during the OU2 Remedial Investigation, additional contaminants, including pesticides and herbicides, were discovered in surface soils of OU2 and in several buildings on the Dico property. OU4 was then designated to address the buildings and surrounding soils and drainage areas on the Dico property and a drainage ditch just east of the Dico property.

OU4 currently includes portions of the Dico property including Buildings 1 through 3; foundations of the Maintenance Building; Buildings 4 and 5 and the Western Annex of Building 3; soil and sediment associated with the former aldrin tank; the South Pond Area; the area associated with completed soil disking operations; and the low-lying area south and east of the Dico property up to the railroad spurs owned by the Union Pacific Railroad.

The primary contaminants of concern detected in the OU4 buildings (Buildings 1 through 5 and the Maintenance Building) were aldrin, dieldrin, chlordane, and polychlorinated biphenyls. The highest levels of aldrin, dieldrin, and chlordane were detected in the concrete floor of the Maintenance Building, in association with the aldrin tank and annex structure. Lower levels of these contamination were detected in Buildings 2, 3 and 4. PCBs were detected in the insulation of Buildings 2, 3, 4, 5 and the Maintenance Building, with the highest concentration being detected in Building 3. However, the Maintenance Building, Buildings 4 and 5, and the Western Annex to Building 3 have been demolished.

Contaminants of Potential Concern detected in the surface soils at OU4 included aldrin, dieldrin, and chlordane. The pesticides were detected above health-based cleanup levels at numerous locations across OU4. COPCs detected in the surface soils in the SPA of OU4 included aldrin, dieldrin, and chlordane. These pesticides were detected in the surface soils along the northwestern edge of the South Pond, in sediment samples from the South Pond, and in samples collected from the east drainage ditch.

Several removal actions have occurred at the Site to address the contamination in the soils and buildings. The removal action for the buildings addressed contamination associated with Dico Buildings 1 through 5, the Maintenance Building, and the former aldrin mixing tank, annex and surrounding soils. The removal action included the following: cleaning the interior surfaces of the buildings; removal of surface soils that had been impacted by contaminants released to the outside; demolition and disposal of the aldrin tank and annex structure; removal of impacted soils surrounding the aldrin tank; repairing damaged and exposed building insulation and encapsulation of PCBs contained within the insulation materials; and application of a protective surface coating to walls and floors to encapsulate any remaining COPC residues and PCBs to prevent direct contact.

The removal action for the soils included excavation and capping of contaminated soil. Soils from low lying drainage areas were excavated and disposed of at an offsite facility. An asphalt cap was constructed over the remaining contaminated impacted soil areas to address the direct contact exposure route. However, contamination has not been removed from the SPA due to concerns over impacts to wetlands.

As part of the fifth five-year review, sediment data from the SPA was compared to ecological screening levels. It was found that the quality of the historic sediment data was an issue. Detection limits were at times orders of magnitude above ecological screening levels, and only limited sampling of the pond had been completed. However, even when adequate detection limits were used, pesticide concentrations exceed ecological screening levels. In the case of aldrin, in particular, the screening level hazard quotient was over 400,000. The purpose of the risk assessment is to evaluate risk using data that meets data quality objectives. In turn, this will enable the EPA to determine the protectiveness of the current remedy.

3.0. HABITAT AND ECOLOGY

Des Moines has a continental climate that is characterized by hot summers and cold winters. Precipitation is highest in the summer months. The terrain in and around Des Moines is gently rolling. Surface water drainage is generally to the southeast, to the Des Moines River and its tributaries. The Site is located in the floodplain of the Raccoon River, which is a tributary to the Des Moines River (Figure 1). The surrounding area is industrial and commercial, with some recreational park land. The Raccoon River is listed as a high priority impaired water due to bacteria and nutrients.

Given the urban and industrial nature of the Site, permanent habitat for threatened and endangered species is not likely to exist; however, it is possible that certain threatened and endangered species are transient at the Site. Table 1 provides information on the protected species and species of concern in Polk County.

The SPA would be considered a forested palustrine wetland. The ecology of these ponds and floodplain areas is dominated by woody vegetation. Wetlands function as an important ecological resource by providing habitat for birds and animals, especially semi-aquatic birds and mammals, as well as amphibians and reptiles.

4.0. SITE INVESTIGATION

The site investigation included the collection of data necessary to evaluate the exposure and effects of COPCs on ecological assessment endpoints. Specific information pertaining to field sampling, including standard operating procedures and quality assurance and quality control can be found in the field sampling and quality assurance and quality control plans for this site (USEPA, 2014a; USEPA, 2014b). The following data was collected in April of 2015:

> Soil – Seven additional soil samples were collected at the Site to characterize current conditions (Figure 2). Soil sampling focused on the soil surrounding the South Pond to determine if contamination from the former facility is impacting surrounding areas due to deposition and run-off.
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> Surface Water – Twelve surface water samples were collected to further characterize current conditions in the South Pond and adjacent drainage way (Figure 2).
>
> Sediment Sampling – Twelve sediment samples were collected to further characterize current conditions in the South Pond and adjacent drainage way. Sediment samples were co-located with surface water samples (Figure 2).

5.0. PROBLEM FORMULATION

The problem formulation phase establishes the goals, breadth, and focus of the ERA (USEPA, 1997). This critical component of the process is the development of assessment endpoints, based on a well-defined site conceptual model. Defining the ecological problems to be addressed involves identifying toxic mechanisms of the COPCs, characterizing potential receptors, and estimating exposure and potential risks.

5.1. CONTAMINANTS OF POTENTIAL CONCERN

Based on sampling events conducted during previous investigations, the primary COPCs are organochlorine insecticides (aldrin/dieldrin and chlordane). Because PCBs have also been identified as COPCs in the buildings north of the Site, potential releases of these contaminants were also evaluated. Additional pesticides were also evaluated at the Site, including heptachlors and DDT.

5.2. CHARACTERIZATION OF ECOLOGICAL EFFECTS OF COPC s

Organochlorine pesticides are chlorinated hydrocarbons used extensively from the 1940s through the 1960s in agriculture and mosquito control. Representative compounds in this group include DDT, methoxychlor, aldrin/dieldrin, chlordane, toxaphene, mirex, kepone, lindane, and benzene hexachloride. One of the primary mechanisms of toxicity of organochlorine pesticides is that effectively bind to sodium channels in neurons increasing permeability to sodium. This increased permeability facilitates uncoordinated discharge of neurons, which leads to the failure of the central nervous system.

PCBs belong to a broad family of man-made organic chemicals known as chlorinated hydrocarbons. PCBs were first introduced into commerce in 1929 and became widely used in electrical transformers, cosmetics, varnishes, inks, carbonless copy paper, pesticides and for general weatherproofing and fire-resistant coatings to wood and plastic. PCBs have been shown to have toxic effects on various organs including tissues of the nervous, reproductive, and immunologic systems.

Both organochlorine insecticides and PCBs are considered Persistent Organic Pollutants. POPs are toxic chemicals that adversely affect the environment. Because of their chemical structure, they persist for long periods of time in the environment and can bioaccumulate in the food chain. The primary COPCs at the site, aldrin/dieldrin, chlordane and PCBs, are on EPA's list of the "Dirty Dozen." Detailed toxicity profiles for COPCs at the site can be found in Appendix A.

5.3. MIGRATION PATHWAYS

The sources of contamination in the SPA include the historical pesticide formulation, storage and handling operations at the Site, as well as the PCBs found in the buildings associated with OU4. The following migration pathways exist at the Site:

> Soil-to-Surface Water/Sediment Migration
> Surface Water/Sediment to Soil Migration
> Biological/Food Chain Transfer

The following subsections present a discussion of each potential route of contaminant migration for the Site.

5.3.1. Soil to Surface Water/Sediment Migration. Contaminants from source areas may be transported by the wind or surface water runoff and deposited down gradient in the floodplain of the Raccoon River, including the surface water and sediment of the SPA and soils of the forested area surrounding the pond.

5.3.2. Sediment/Surface Water to Soil Migration. Contaminated sediment and surface water can be a source of contamination to surrounding soils during high water events.

5.3.3. Biological/Food Chain Migration. Biological migration may occur through uptake, bioaccumulation, and food-chain transfer. Bioaccumulation can be predicted from log octanol-water partitioning when the log K_{ow} lies between 2 and 6. The log K_{ow} values for the COPCs at the site suggest a high potential for bioaccumulation and biomagnification. Further, the COPCs identified at the Site are listed in Table 4-2 of *Bioaccumulative Testing and Interpretation for the Purposes of Sediment Quality Assessment, Status and Needs (*EPA, 2000). The EPA generally considers contaminants in this list to be of concern for biological transport.

5.4. ASSESSMENT ENDPOINTS

An assessment endpoint is "an explicit expression of the environmental value that is to be protected" (USEPA, 1992). A measurement endpoint is defined as "a measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint" and is a measure of biological effects (e.g., mortality, reproduction, growth) (USEPA, 1992). Measurement endpoints are frequently numerical expressions of observations (e.g., toxicity test results, community diversity measures) that can be compared statistically to a control or reference site to detect adverse responses to a site contaminant.

The conceptual model (Figure 3) establishes the complete exposure pathways that would be evaluated in the ERA and the relationship of the measurement endpoints to the assessment endpoints. The relationship of the selected measurement endpoint to the assessment endpoints are presented in Table 2.

5.4.1. AE#1 Survival, Growth and Reproduction of Be nthic Macroinvertebrates. Benthic invertebrate communities are expected to be sensitive to the COPCs at the Site due to direct exposure to sediment. Therefore, survival, growth and reproduction of benthic macroinvertebrate communities exposed to COPCs in sediment was selected as an assessment endpoint.

Risk Question: Are concentrations of COPCs in sediment and surface water sufficient to adversely affect the survival, growth and reproduction of benthic macroinvertebrates?

Measure Effects: The maximum and 95% Upper Confidence Limit of the mean (or similar EPC term) of measured concentrations of COPCs in sediment and surface water were compared to toxicity benchmark values for sediment.

5.4.2. AE#2 Survival, Growth and Reproduction Soil Invertebrates. Terrestrial invertebrates that are directly exposed to contaminated soil typically have the highest exposure to the COPCs at the site. Further, aldrin/dieldrin and chlordane are insecticides that are persistent in the environment. Therefore, survival, growth and reproduction of soil invertebrates exposed to COPCs in soil were selected as an assessment endpoint.

Risk Question: Are concentrations of COPCs in soil sufficient to adversely affect the survival, growth and reproduction of soil invertebrates?

Measure Effects: The maximum and UCL95 of measured concentrations of COPCs in soil were compared to toxicity benchmark values for soil.

5.4.3. AE#3 Survival, Growth and Reproduction of In sectivores. Food chain transfer of contaminants from terrestrial soil invertebrates to higher trophic level organisms is an important exposure pathway given the bioaccumalative nature of the COPCs at the site. Therefore, survival, growth and reproduction of terrestrial insectivore communities exposed to COPCs is included as an assessment endpoint. The short-tailed shrew (*Blarina brevicauda*) and American woodcock (*Scolopax minor*) have been selected as receptors for this assessment endpoint.

Risk Question: Are concentrations of COPCs in soil sufficient to adversely affect the survival, growth and reproduction of insectivores?

Measure Effects: The maximum and UCL95 of measured concentrations of COPCs in soil were used in food chain models to calculate dietary exposure concentrations for insectivorous birds and mammals. Receptor species representative of the feeding guilds identified as AEs for this ERA were selected based on their potential to utilize the site, potential exposure to site-related COPCs based on feeding habits, and availability of data to determine exposure parameters.

5.4.4. AE#4 Survival, Growth and Reproduction of Ca rnivores. Food chain transfer of contaminants from small mammals, birds and insects to higher trophic level carnivores is an important exposure pathway given the bioaccumalative nature of the COPCs at the site. Therefore, survival, growth and reproduction of terrestrial carnivore communities exposed to COPCs is included as an assessment endpoint. The long-tailed weasel (*Mustela frenata*) and red-tailed hawk (*Buteo jamaicensis*) have been selected as receptors for this assessment endpoint.

Risk Question: Are concentrations of COPCs in soil sufficient to adversely affect the survival, growth and reproduction of carnivores?

Measure Effects: The maximum and UCL95 of measured concentrations of COPCs in soil were used in food chain models to calculate dietary exposure concentrations for carnivorous birds and mammals. Receptor species representative of the feeding guilds identified as AEs for this ERA were selected based on their potential to utilize the site, potential exposure to site-related COPCs based on feeding habits, and availability of data to determine exposure parameters.

5.4.5. AE#5 Survival, Growth and Reproduction of Pi scivores. Food chain transfer of contaminants from fish to higher trophic level carnivores is an important exposure pathway given the bioaccumalative nature of the COPCs at the site. Therefore, survival, growth and reproduction of piscivore communities exposed to COPCs is included as an assessment endpoint. The Great Blue Heron (*Ardea herodias*) has been selected as receptors for this assessment endpoint.

Risk Question: Are concentrations of COPCs in sediment sufficient to adversely affect the survival, growth and reproduction of piscivores?

Measure Effects: The maximum and UCL95 of measured concentrations of COPCs in sediment were used in food chain models to calculate dietary exposure concentrations for piscivorous birds. Receptor species representative of the feeding guilds identified as AEs for this ERA were selected based on their potential to utilize the site, potential exposure to site-related COPCs based on feeding habits, and availability of data to determine exposure parameters.

6.0. RISK CHARACTERIZATION

In the ecological risk characterization, data on exposure and effects are integrated into a statement about risk to each assessment endpoint. A weight-of-evidence approach is used to interpret the implications of different studies and tests for each assessment endpoint. Risk characterization and the evaluation of potential uncertainties constitute the final phase of the risk assessment process.

6.1. EVALUATION OF DIRECT EXPOSURE

Direct exposure to contaminated soil and sediment is evaluated for AE#1 and AE#2 using the Hazard Quotient approach. An HQ is the ratio of the estimated exposure of a receptor at a site to a benchmark exposure that is believed to be without significant risk of unacceptable adverse effect on survival, growth, or reproduction. Conservative benchmark values are used to ensure that potential ecological threats are not overlooked. The benchmarks for chronic No-Observable-Adverse-Effect-Levels are exposure concentrations at which ecological effects are not expected.

HQ = Exposure Point Concentration/Screening Level Benchmark

Exposure may be expressed in a variety of ways, including:

- Concentrations in environmental media (water, soil, sediment, diet)
- Concentrations in the tissues of the exposed receptor and/or
- Amount of chemical ingested by a receptor

In all cases, the benchmark toxicity value must be the same type as the exposure estimate.

If the value of the calculated HQ is less than or equal to 1.0, risks to exposed organisms are thought to be minimal. If the HQ exceeds 1.0, the potential for adverse effects in exposed organisms may be of concern, with the probability and/or severity of the adverse effect tending to increase as the HQ value increases.

6.1.1. Calculation of the Exposure Point Concentrat ion. The SPA is considered a single exposure area. There are 12 sediment and surface water samples from the pond, and seven soil samples from the perimeter of the pond (Figure 2). ProUCL version 5.0.0 (USEPA, 2013) was used to calculate the maximum and UCL95 for all COPCs. Several COPCs had high frequencies of non-detect values. When all of the reported values are non-detect, one EPC term is estimated based on the ½ the highest Reporting Limit. If less than four detected values are present in the dataset, the EPC term is calculated based on the median of the detected and non-detect values (USEPA, 2013). For datasets with low frequencies of non-detects, the mean and UCL95 are based on the recommendations provided in ProUCL, generally either Kaplan-Meier or Gamma statistics. However, when the UCL95 statistic recommended in ProUCL exceeds the maximum detected value, as was the case for dieldrin and chlordane in soil, the 95% Chebyshev UCL was used as the EPC term. The EPCs for sediment, surface water and soil can be found in Tables 3-5, and all ProUCL results can be found in Appendix D.

6.1.2. Screening Level Benchmarks. The primary ecological effects of interest for the COPCs at this site are direct toxicity; bioaccumulation within the food chain; and adverse effects on survival, growth and reproduction of potentially exposed ecological receptors. Direct effects were evaluated by comparing measured COPCs to screening level benchmarks. Sediment was screened against consensus-based Sediment Quality Guidelines (Threshold and Probable Effect Concentrations) (MacDonald *et al.*, 2000) and Equilibrium Partitioning Sediment Benchmarks (USEPA, 2003a; USEPA, 2008). Ecological Soil Screening Levels (USEPA, 2007a; USEPA, 2007b) were used to screen soil. Finally, USEPA Region 5 Ecological Screening Levels (USEPA, 2003b) were used for all media when one of the above referenced screening values was unavailable.

6.1.3. HQ-Based Risk Characterization. If the maximum concentration did not exceed the screening level, the COPC was removed from further evaluation at the site. If the maximum concentration exceeds screening levels, further risk evaluation was conducted using the UCL95 (or alternative EPC term).

6.1.4. Survival, Growth and Reproduction of Benthic Macroinvertebrates. Risk to benthic macroinvertebrates was evaluated by comparing maximum concentrations to conservative screening levels (TEC or ESL). The TEC is a concentration below which effects are not likely to occur, and ESLs are similarly protective. Screening level results for AE#1 can be found in Table 6. Only two COPCs were screened out, d-BHC and endrin aldehyde. A screening value is not available for endrin ketone, therefore it was carried through the screen due to uncertainty.

COPCs that exceeded the TEC or ELS were evaluated further by comparing the UCL95 (or alternative EPC term) to PECs and ESBs. PECs are concentrations above which effects are probable (MacDonald *et al.*, 2000). In addition, because organic carbon is a factor controlling the bioavailability of nonionic organic compounds in sediments, ESBs were calculated on an organic carbon basis for a number of COPCs and compared to ESB_{WQCs} and ESB_{Tier2} values (USEPA, 2003a; USEPA, 2008). ESBs were calculated based on the UCL95 for both the COPC and total organic carbon at the site. The conversion from dry weight to organic carbon– normalized concentration was done using the following formula:

$$\mu g \text{ chemical}/g_{oc} = \mu g \text{ chemical}/g_{dw} \div (\% \text{ TOC} \div 100)$$

Results can be found in Table 7. It should be noted that the PEC and ESB for dieldrin were used for comparison to aldrin because aldrin is rapidly converted to dieldrin in the environment, and both have similar chemical structures. Consequently, toxicity data on aldrin is limited. The primary COPCs at the site (aldrin/dieldrin and chlordane) exceed the PEC and ESB in the SPA. The elevated HQ_{PEC} for both compounds indicates risk to benthic macroinvertebrates is probable. Further, the ESB evaluation shows that the organic carbon in the system is not decreasing the bioavailability below the ESBs, indicating that these pesticides are partitioning into the interstitial pore water at concentrations that exceed the final chronic values for water quality. The results for aldrin, dieldrin and chlordane indicate that the risk to benthic macroinvertebrates is substantial in the SPA.

Several other pesticides, as well as Aroclors, also exceed either PECs and/or ESBs. However, in most cases, these results are calculated based on a non-detect EPC term. Consequently, there is substantially more uncertainty associated with the risk evaluation for these COPCs.

6.1.5. Survival, Growth and Reproduction of Soil Invertebrates. Risk to soil invertebrates was evaluated by comparing maximum concentrations to ESLs because Eco-SSLs for soil invertebrates are not available for the COPCs at the site. Screening level results for AE#2 can be found in Table 8. The benzene hexachlorides, other than G-BHC, did not exceed ESLs. Similarly, the metabolites of DDT (DDD and DDE) did not exceed ESLs. Also, endosulfan I and II, and heptachlor epoxide, did not exceed ESLs.

Hazard quotients based on the UCL95 (or alternative EPC term) can be found in Table 9. Hazard quotients for aldrin, dieldrin, chlordane and Aroclor 1260 indicate probable risk to soil invertebrates. Several other pesticides and Aroclors also exceed ESLs. However, in most cases, these results are calculated based on a non-detect EPC term. Consequently, there is substantially more uncertainty associated with the risk evaluation for these COPCs.

6.2. FOOD CHAIN EXPOSURE TO WILDLIFE RECEPTORS

Risks to wildlife were modeled using food chain models rather than comparisons based on direct exposure. Food chain models are based on ingestion as the primary exposure route. The basic equation for calculation of the HQ for a wildlife receptor exposed to a chemical via ingestion is:

$HQ_{i,j,r} = C_{i,j} * (IR_{j,r}/BW_r) *AUF_r / TRV_{i,r}$

Where:

$HQ_{i,j,r}$ = HQ for the exposure of receptor "r" to chemical "i' in medium "j"
$C_{i,j}$ = Concentration of chemical "i" in medium "j" (mg/kg)
$IR_{j,r}$ = Ingestion rate of medium "j" by receptor "r" (kg/d)
BW_r = Body weight of receptor "r" (kg)
AUF_r = Area Use Factor of receptor "r" as a fraction of the receptor's home range that is included in the exposure area being evaluated.
$TRV_{i,r}$ = Oral Toxicity Reference Value for chemical "i' in receptor "r" (mg/kg bw/d)

6.2.1. Wildlife Exposure Factors. Exposure factors and ingestion rates for each representative wildlife receptor can be found in Appendix E. Wildlife exposure factors were selected to represent average year-around exposure to adults. Although AUFs can be adjusted for wildlife receptors based on home ranges and seasonal use, an AUF of one is used in the dose equations for this risk assessment.

6.2.2. Estimates of Chemical Concentrations in Diet . For wildlife, the SPA is considered a single exposure area. The UCL95 was used to estimate the concentrations of chemicals in the diet. EPCs for sediment, surface water and soil can be found in Tables 3 through 5. Because data is only available for soil, sediment and surface water, concentrations in prey items were modeled based media specific concentrations. For terrestrial receptors, soil-to-invertebrate and soil-to-mammal Bioaccumulation Factors were used to estimate prey concentrations (HAZWRAP, 1994; USEPA, 2007a; USEPA, 2007b). Soil invertebrate and mammal BAFs are calculated by dividing the concentration of chemical "i" in tissue by the concentration of chemical "i" in soil. Where BAFs could not be identified, a default BAF value of 1.0 was used. BAFs can be found in Table 9, and modeled prey concentrations can be found in Table 11.

For piscivores, COPC concentrations in fish were based on Bioconcentration Factors identified in the ECOTOX, Version 4.0 database (USEPA, 2015). BCFs are calculated by dividing the concentration of chemical "i" in tissue by the concentration of chemical "i" in surface water.

BCF data on small fish species, such as fathead minnows, was used when available. In some cases, BCFs for larger fish were used due to lack of data on smaller fish. Where Ecotox data could not be identified, modeled fish concentrations were based on a surrogate chemical. For example, the BCF for Aroclor 1254, a more highly chlorinated Aroclor, was used to model concentrations for Aroclor 1221. This was done to maintain conservatism in the risk estimates. BCFs can be found in Table 10, and prey concentrations can be found in Table 11.

6.2.3. Toxicity Reference Values. TRVs for wildlife were obtained by conducting a literature search to obtain information on the ecological effects of COPCs identified at the site. This search identified mechanisms of toxicity for COPCs and evaluated exposure-response data. TRVs based on No Observed Adverse Effect Levels and Lowest Observed Adverse Effect Levels for dietary effect concentrations for avian and mammalian receptors were identified. Detailed information on TRVs can be found Appendix F. In some cases, a LOAEL value was not available for a COPC. However, for all COPCs where the LOAEL was not available, the HQ_{NOAEL} did not exceed one; therefore, a LOAEL value was not necessary for the risk characterization.

6.2.4. HQ-based Risk Characterization . For assessment of effects to wildlife through the food chain, if neither the NOAEL nor LOAEL based HQ is greater than or equal to 1.0, it is concluded that there is no model-calculated risks to the given receptor. If the NOAEL based HQ is greater than or equal to 1.0, but the LOAEL based HQ is less than one, it is concluded that the model-calculated risks to the given receptor cannot be determined. If the LOAEL based HQ is greater than or equal to 1.0, it is determined that there is model-calculated risks to a given receptor.

6.2.5. Survival, Growth, and Reproduction of Terres trial Insectivores.
The short-tailed shrew and American woodcock were selected as receptors for AE#3. Exposure factors for wildlife receptors can be found in Appendix E, and TRVs for birds and mammals can be found in Appendix F. The Average Daily Dose equations for terrestrial insectivores can be found in Table 12. Model-calculated risk to terrestrial insectivores was found for dieldrin, as the HQ_{LOAEL} for both receptors exceeds one. For Aroclor 1248, the HQ_{LOAEL} exceeded one for the short-tailed shrew, indicating model-calculated risk. However, this result is based on non-detect data, resulting a high degree of uncertainty. For several Aroclors, DDE, and chlordane, the HQ_{NOAEL} exceeds one, but the HQ_{LOAEL} did not, indicating unknown risks.

6.2.6. Survival, Growth and Reproduction of Terrest rial Carnivores.
The long-tailed weasel and red-tailed hawk were selected as receptors for AE#4. Exposure factors for wildlife receptors can be found in Appendix E, and TRVs for birds and mammals can be found in Appendix F. The Average Daily Dose equations for terrestrial carnivores can be found in Table 12. Model-calculated risk to terrestrial carnivores was found for dieldrin, as the HQ_{LOAEL} for both receptors exceeded one. For Aroclor 1221, 1242, and 1248, the HQ_{LOAEL} exceeded one for the long-tailed weasel, indicating model-calculated risk. However, these results are based on non-detect data, resulting a high degree of uncertainty. For several Aroclors, DDD, DDE, DDT and chlordane, the HQ_{NOAEL} exceeded one for one or both of the receptors, but the HQ_{LOAEL} did not, indicating unknown risks.

6.2.7. Survival, Growth and Reproduction of Piscivo res
The Great Blue Heron was selected as receptors for AE#5. Exposure factors for wildlife receptors can be found in Appendix E, and TRVs for birds and mammals can be found in Appendix F. The Average Daily Dose equations for piscivores can be found in Table 12. Model-calculated risk to piscivores was found for Aroclor 1016, 1221, 1232, 1248, 1254, and 1260. The HQ_{LOAEL} exceeds one for all of these COPCs; however, these results are based on modeled fish concentrations from surface water concentrations that are non-detect; therefore, there is a large degree of uncertainty. For DDE, dieldrin and toxaphene, the HQ_{NOAEL} exceeded one, but the HQ_{LOAEL} did not, indicating unknown risks.

7.0. UNCERTAINTIES

There are inherent uncertainties in the risk assessment process; however, knowledge of the cause and potential effects of these uncertainties permits the risk assessor and risk manager to interpret and use the risk assessment in making site management decisions. Sources of uncertainty fall into several categories including analytical and sampling design, assumptions, natural variability, error, and insufficient knowledge. Risk assessment is essentially the integration of the exposure and hazard assessments. Sources of uncertainty associated with either of these elements may contribute to overall uncertainty. In addition, the risk assessment procedure itself can contribute to overall uncertainty. Each of these sources of uncertainty can be addressed differently; therefore, understanding how each of these sources of uncertainty is handled within the risk assessment is integral to the overall interpretation.

7.1. ANALYTICAL DATA
The analytical database has inherent uncertainties. For example, the contribution of the chemical of potential concern across the site was assumed to coincide with receptor contact with environmental media. The degree to which this assumption is met is not quantifiable and direction of bias cannot be measured.

In many instances, results were reported as non-detect. In those cases, ProUCL was used to calculate exposure point concentrations. However, there is substantial uncertainty when using ½ the reporting limit or the median of a dataset in which the majority of the data is non-detect. In some cases, the reporting limits were reported at up to 20 times the detection limit due to laboratory interferences. This greatly increased the EPC term for a number of COPCs.

The use of non-detect data to calculate prey concentrations further increases this uncertainty. For example, model-calculated risk for the heron exposed to Aroclors and toxaphene exceeded one; however, the entire surface water dataset for these COPCs was non-detect, and the detection limits for surface water were elevated, resulting in high modeled concentrations in the fish tissue.

7.2. UNCERTAINTY OF THE CONCEPTUAL MODEL
Organisms use their environment unevenly, and differential habitat use based on habitat quality is a source of uncertainty. Natural variability is an inherent characteristic of ecological systems and stressors. Additionally, there is a limit to our understanding of the population dynamics of most species, and the community interactions that exist between species. Limited knowledge of

population ecology is fundamental in the interpretation of measurement endpoints as they relate to the assessment endpoint.

Also, the exposure model is based on the “average” behavior of a species. As such, extremes of behavior are not incorporated into the overall exposure assessment. While these assumptions may not apply to all individuals, they are generally applicable at the population level and while not all of the biological variability is captured in the assessment, no directional bias is introduced.

Finally, an additional source of uncertainty is the exclusion of the air pathway due not only to lack of data, but also due to the lack of physiological and toxicological data necessary to evaluate this exposure pathway. While this may not generate significant amounts of additional COPC exposure, it may be a contributor to overall risks.

7.3. UNCERTAINTIES ASSOCIATED WITH TOXICOLOGICAL STUDIES

7.3.1. Variable Toxicity in the Aquatic Environment. There are specific uncertainties related to toxicity of contaminants in the aquatic environment. Temporal variations and variations related to climatic conditions can significantly increase or decrease the toxicity of COPCs. These variations may affect the concentration of individual COPCs, other essential nutrients, and TOC, which in turn affects toxicity and bioavailability.

7.3.2. Extrapolation of Laboratory Toxicity Tests to Natural Conditions. The toxicological data that were used to evaluate the implications of estimated doses to receptors of concern constitute a source of uncertainty in the assessment. For example, organisms used in toxicity tests conducted in laboratories are not necessarily subjected to the same degree of non-toxicant related stress as receptors under natural conditions. In general, laboratory toxicity tests use single toxicants while receptors in the field are exposed to multiple toxicants. Multiple toxicants can behave independently (such as when modes of action are very different), they may act additively (or synergistically), such that expression of effects is driven by several toxicants simultaneously, or they may interact antagonistically. Cumulative effects of multiple stressors are not necessarily the same. It is difficult to predict the direction of bias in this case as laboratory conditions and natural conditions each may stress organisms but the relative magnitude and physiological implications of these stresses are not actually comparable. Also, due to the differences in the health of laboratory and field populations, differences in genetic diversity (and hence resistance to stressors), and possible impacts of non-toxicant stressors, some unavoidable uncertainty exists when extrapolating laboratory derived data to field situations. Given these factors, the difference between conducting laboratory tests with single stressors as compared to natural conditions with multiple stressors adds to the uncertainty regarding the conclusions of this risk assessment. In addition, although it is believed that the important potential sources of toxicity have been addressed, it is possible that there are unmeasured or unconsidered stressors at the site.

7.3.3. Differences between Responses of Test Species and Receptor Species. Toxicological studies also use species that, while they may be related to the taxa, or species, being evaluated at the site, are rarely identical. In general, the greater the taxonomic difference, the greater the uncertainty associated with the application of study data to the receptors of potential concern.

7.3.4. Differences in Chemical Forms of Contaminant s. Many toxicological studies use chemical formulations and/or administration methods that do not relate well to field exposures.

7.3.5. Variability in Toxicity Reference Values. In some cases there may be a significant difference between the no effect and lowest effect level toxicity reference values used to estimate risk to a receptor. The actual point at which effects are seen could be anywhere in the range between these two values. The greater the range between the two values, the greater the uncertainty associated with the conclusions.

7.3.6. Extrapolation of Individual Level Effects to Population-Level Effects. Laboratory based bioassays or toxicity tests measure the response of a laboratory "population" of organisms to the stressor under consideration. These populations generally represent a low diversity genetic stock and, as such, probably do not represent the range of sensitivities and tolerances characteristic of natural populations. As such, there is uncertainty associated with extrapolation of laboratory population responses to populations in natural systems. This uncertainty is probably not directionally biased as both sensitive and tolerant individuals may be missing from the laboratory populations.

7.4. UNCERTAINTIES ASSOCIATED WITH THE EXPOSURE ASS ESSMENT

The SPA is less than one acre. It was assumed that the area-use-factor is 100% for each wildlife receptor. Other than the short-tailed shrew, this assumption likely results in an over-estimate of risk.

An additional source of uncertainty associated with exposure calculations is that feeding rates were assumed to not vary with season, breeding condition, or with other local factors. Reported feeding rates undoubtedly vary with all of these factors because metabolic needs change as does food availability. Conservative estimates of feeding rates were derived from studies that reported for multiple seasons.

Further, dietary compositions were simplified for each wildlife receptor. For example, herons consume a variety of aquatic species, as well as some terrestrial prey. Red-tail hawks are opportunistic hunters that feed on a variety of small animals, not just small mammals. However, the direction and magnitude of the uncertainty related to simplifying diets is not known. Finally, diet composition was assumed to not vary with season or local conditions. As with feeding rates, this assumption is unlikely to be met but the direction of bias is not measurable.

Finally, all of the prey concentrations were modeled based off of BAFs/BCFs from a variety of sources (HAZWRAP, 1994; USEPA, 1995, ECOTOX, 2015). Modeling always introduces more uncertainty in comparison to having data from prey inhabiting the Site. For example, there are a number of surface water-to-fish BCFs for each COPC available from the ECOTOX database.

Only one value was selected. Uncertainty was somewhat reduced by selecting BCFs based on small laboratory fish species; however, there is certainly a range of BCFs and the true concentration in small fish from the SPA could be more reliably estimated by collection of fish from the pond, which was not done.

7.5. UNCERTAINTY IN EVALUATING ECOLOGICAL RISK

There is uncertainty associated with the interpretation of hazard quotients. The calculated hazard quotients are based on a literature benchmark. Data are generally not available on the slope of the toxicity curve for most contaminants and little is known about the interaction of the contaminant on the slope of the toxicity curve. For this reason, as well as others discussed in this section, the numerical value of a hazard quotient has little absolute meaning. For example, hazard quotients above 1 indicate a potential risk relative to the toxicological benchmark, but a hazard quotient of 10 does not mean that the risk is 10 times greater.

There is also the issue of immeasurable long-term effects and adaptations. Due to the complexity of community and population dynamics, it is not currently possible to evaluate all possible effects by implementation of even the most ambitious studies. The information presented, while complete and accurate, may miss long-term adverse effects of contaminants on receptors or may fail to address adaptation to conditions that impart some immunity to contaminant effects. In addition, ecological functional redundancies contributed by unevaluated species (multiple species may fill the same niche) may provide resilience against adverse effects at the community and ecosystem levels and sensitivities may be present in other populations that have not been evaluated in the current risk assessment. In either case, the results presented are only snap-shots of conditions as they exist at the site and it is essentially certain that not all of the underlying variability and stressor effects have been quantified. As such, it is important for the reader to recognize that large uncertainties exist regarding community and population health, but that these uncertainties most likely do not directionally bias conclusions.

8.0. SUMMARY AND CONCLUSIONS

The primary COPCs at the site are aldrin, dieldrin, and chlordane. PCBs are also a potential concern due to their presence in the buildings on the Site. Aldrin tanks were stored at the SPA, and aldrin contamination is still present at the Site. However, it is Aldrin's breakdown product, dieldrin that appears to be the primary risk driver. Dieldrin contamination at the SPA is widespread, as it was detected in all sediment and soil samples. Dieldrin was also detected in surface water at locations 8 and 11. Modeled-risks are probable for all of AEs, except AE#5 (piscivores), in which the risk is unknown ($HQ_{NOAEL} > 1$, but $HQ_{LOAEL} < 1$). Therefore, it is concluded that significant ecological risk is likely at the SPA due to dieldrin contamination. Also, chlordane was detected in all of the sediment and soil locations and in surface water at Location 8. Potential risk due to Chlordane was identified for soil invertebrates and benthic macroinvertebrates, but not for wildlife receptors at the site.

Of the Aroclors evaluated, only Aroclor 1260 was detected in soil and sediment at the site. Probable risks to soil invertebrates and benthic invertebrates was found for Aroclor 1260. Risks were unknown for terrestrial wildlife receptors with HQ_{NOAEL} values >1, but HQ_{LOAEL} values < 1. Aroclor 1260 was not detected in surface water; therefore, modeled risks to the heron are highly uncertain. Although potential risk due to other Aroclors was identified for all AEs, this risk is uncertain, as the data was non-detect.

Other pesticides were evaluated in the risk assessment, even though they were not identified as site-specific COPCs. Several of these pesticides were detected in soil and sediment. The extent to which these pesticides were related to intended use in the past is unknown. For example, DDT may have been applied at the SPA (or in the vicinity). The impact of these additional pesticides on ecological receptors is likely to be additive to the overall effects of the site-related COPCs at the Site.

Direct exposure to sediment and soil impacting the soil invertebrate and benthic macroinvertebrate populations at the SPA is a probable risk at the site. Food chain exposure to dieldrin to wildlife receptors with small home ranges, such as small mammals, is also likely to be significant. However, the small size of the site may limit food chain exposure to higher trophic level wildlife receptors. For receptors with large home ranges (red-tailed hawks, American woodcocks and long-tailed weasels), true exposure is likely to be less than the exposure assumed in this risk assessment. The habitat south of the site includes woods and riparian zones that would also provide areas for foraging, and human encroachment on the SPA may be a deterrent to wildlife to some degree.

9.0. REFERENCES

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USEPA, 2000. Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment, Status and Needs. February 2000. EPA 823-R-00-001.

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APPENDIX A: TOXICITY PROFILES

Aldrin/Dieldrin

Based on information from the EcoSSL Toxicity Profile (USEPA, 2007)

Aldrin (1,2,3,4,10,10-hexachloro-1,4,4",5,8,8"-exo-1,4-endo-5,8-dimethano-naphthalene or HHDN) and its epoxide derivative dieldrin (1,2,3,4,10,10-hexachloro-6,7-epoxy- 1,4,4",5,6,7,8,8"-octahydro-1,4-endo,exo-5,8-dimethanonaphthalene, or HEOD), are man-made chlorinated cyclodiene insecticides used extensively in the United States from the 1950s to the early 1970s. Aldrin is discussed along with dieldrin as it readily changes into dieldrin when it enters the environment. The trade names used for dieldrin included Alvit, Dieldrix, Octalox, Quintox and Red Shield (ATSDR, 2002). Aldrin and dieldrin were used primarily for the control of termites around buildings, corn pests by application to soil and in the citrus industry (U.S. EPA, 1980). Other uses included crop protection from insects, timber preservation and termite-proofing of plastic and rubber coverings of electrical and telecommunication cables and of plywood and building boards (Worthing and Walker, 1983). The U.S. Department of agriculture canceled all uses of aldrin and dieldrin in 1970. In 1972, however, EPA approved aldrin and dieldrin for use in three instances: 1) subsurface ground insertion for termite control; 2) dipping of non-food plant roots and tops; and 3) moth-proofing in manufacturing processes using completely closed systems (USEPA, 1980 and 1986). Use for termite control continued until 1987 when the manufacturer voluntarily canceled the registration for use in controlling termites. Manufacture in the U.S. ceased in 1989 (ATSDR, 2002).

Dieldrin in the soil environment has low to no mobility. Dieldrin is nonpolar, has a strong affinity for organic matter and sorbs tightly to soil particles. Volatilization is the principal loss process but is slow due to its low vapor pressure and strong sorption. Dieldrin degrades slowly in soil surfaces with a reported half-life of about 7 years in field studies. Dieldrin (and aldrin) applied to soil may also undergo degradation by ultraviolet light to form photodieldrin and this reaction may also occur as a result of microbial activity. In soil, aldrin is converted to dieldrin by epoxidation (ATSDR, 2002).

Dieldrin bioaccumulates in both terrestrial and aquatic systems. As both plants and animals metabolize aldrin to dieldrin via epoxidation, significant levels of aldrin are seldom found in biological matrices. Therefore, most studies focus on dieldrin rather than aldrin. In plants, dieldrin is accumulated primarily in the roots with aerial parts containing smaller concentrations (ATSDR, 2002). In terrestrial organisms, accumulation of dieldrin in fat tissues is known to increase with increasing trophic level of the organism with predators at the top of the food chain tending to have the highest exposure and greatest risk. In mammals, dieldrin is accumulated in adipose tissue, liver and brain. The neurotoxicity of dieldrin to the Central Nervous System is well documented. CNS manifestations originate in neural synapses. Dieldrin prevents the action of the neurotransmitter gamma-aminobutyric acid (GABA) by binding to the picrotoxin binding site of the GABA-receptor-ionophore complex (Matsurmura and Giashudding, 1983). GABA is secreted only by nerve terminals in the spinal cord, the cerebellum, the basal ganglia, the retina, and areas of the cortex. It is thought to cause inhibition of neurotransmission by binding the complex and creating a structural alteration preventing influx of Cl- and repolarization of the membrane (Bloomquist and Soderlund, 1985). Basal ganglia innervation by GABA neurons originating from the cortex provide inhibitory input. GABA, therefore, lends stability to motor control systems (Guyton 1991). Without the inhibitory effect of the GABA transmitter, there is uncontrolled motor stimulation leading to convulsions and other CNS manifestations of dieldrin. In mammals, clinical signs of toxicity include depressed activity, followed by hyperexcitability, tremors and convulsions (Coats, 1990; Matsurmura and Giashudding, 1983).

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Aroclors

Based on Information from Eisler (2000)

Aroclor is the trade name used for most of the commercial PCB mixtures created in the United States by the Monsanto Company. These were sold in the US under the name Aroclor followed by a 4-digit number. The first two digits represent the number of carbon atoms (12); the second two digits indicate the percentage of chlorine by mass in the mixture. For example, Aroclor 1260 contains 60% chlorine by mass. Aroclors with lower numbers are “light” oily liquids, while at the higher end they have a “heavier,” more waxy form.

The transport and fate of PCBs in the aquatic environment and their partitioning between sediment, water and organisms depends largely on sorption reactions. In soils, the sorption and retention of PCB congeners is influenced by the number of chlorine atoms in the molecule, and the more highly chlorinated PCBs tend to more strongly bind to soil particles. The soil sorption capacity and bioconcentration factors of PCBs are strongly related to the octanol-water partition coefficient (K_{ow}). The higher K_{ow} values of PCBs is what leads to their bioaccumulation and biomagnification in the food web.

The amount of chlorine largely determines the physical properties of different Aroclors. The toxicology of PCBs varies considerably among congeners, depending on the number and location of chlorines on the biphenyl molecule, and also between animal species due to differences in absorption, metabolism, mechanism of action, and potential toxic effects. Common effects of PCB exposure observed in various animals are summarized in the table below (Hansen, 1994).

System Affected	**Specific Effect**
Hepatic effects	Hepatomegaly, bile duct hyperplasia; Widespread (e.g., rabbit) or focal (e.g., mouse) necrosis; Lipid accumulation, fatty degeneration; Induction of microsomal monooxygenases and other enzymes; Decreased activity of membrane ATPases; Depletion of fat-soluble vitamins; Porphyria
Gastrointestinal effects	Hyperplasia and hypertrophy of gastric mucosa; Gastric ulceration and necrosis; Proliferation and invasion of intestinal mucosa (monkey); Hyperplasia, hemorrhage, necrosis (hamster, cow)
Respiratory system	Chronic bronchitis, chronic cough

Nervous system	Alterations in catecholamine levels; Impaired behavioral responses; Developmental deficits; Depressed spontaneous motor activity; Numbness in extremities
Skin	Chloracne; Edema, alopecia
Immunotoxicity	Altered levels of circulating steroids; Estrogenic, antiestrogenic, antiandrogenic effects; Decreased levels of plasma progesterone; Adrenocortical hyperplasia; Thyroid pathology, changes in circulating thyroid hormones
Reproduction	Increased length of estrus; Decreased libido; Embryo and fetal effects following in utero exposure
Carcinogenesis	Promoter; Attenuation of some carcinogens

References:

Eisler, R. 2000. Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, 2 and Animals. Volume 2 – Organics. Lewis Publishers, Boca Raton, FL. ISBN 1-56670-506-1.

Chlordane

Based on Information from Eisler (2000)

Technical chlordane is an organochlorine compound first introduced into the United States in 1947 in a variety of formulations for use as a broad-spectrum pesticide. By 1974, about 9.5 million kilograms of chlordane were produced annually. Concern over the potential carcinogenicity of chlordane has led to sharply curtailed production. Since 1983, chlordane use in the United States has been prohibited, except for control of underground termites.

Technical chlordane consists of about 45 components, primarily cis-chlordane (19%), trans-chlordane (24%), heptachlor (10%), cis- and trans-nonachlor (7%), and various chlordane isomers (22%). Chemical analysis of technical chlordane is difficult because of analytical interferences from other organochlorine compounds, nonstandardization of analytical techniques, variations in the number and relative composition of components in weathered chlordane, and, uncertainty of structural formulas and other properties of several compounds present.

Past chlordane use, coupled with atmospheric transport as the major route of dissemination, produced global contamination of fish and wildlife resources and human populations. The chemical and its metabolites were frequently detected in all species examined, but usually at low concentrations. Residues in fish muscle sometimes exceeded the U.S. Food and Drug Administration action level of 0.3 mg/kg fresh weight recommended for human health protection. In general, chlordane in animals is highest near areas where the chemical has been applied to control termites; concentrations are highest in fat and liver, especially in predatory species.

The half-life of chlordane in water is comparatively short; cis-chlordane, for example, usually persists less than 18 h in solution. In soils, however, some chlordane isomers persist for 3 to 14 years because of low solubility in water, high solubility in lipids, and relatively low vapor pressure. There seems to be little accumulation of chlordane in crops grown in contaminated soils.

Chlordane is readily absorbed by warm-blooded animals through skin, diet, and inhalation, and distributed throughout the body. In general, residues of chlordane and its metabolites are not measurable in tissues 4 to 8 weeks after exposure, although metabolism rates varied significantly between species. Food chain biomagnification is usually low, except in some marine mammals. In most mammals, the metabolite oxychlordane has proven much more toxic and persistent than the parent chemical.

Many species of aquatic organisms are adversely affected at concentrations in water between 0.2 and 3.0 µg/L technical chlordane. Sensitive bird species had reduced survival on diets containing 1.5 mg chlordane per kilogram in their diet, or after a single oral dose as low as 14.1 mg chlordane per kilogram body weight. Chlordane has produced liver cancer in laboratory strains of domestic mice, but carcinogenicity has not been established in other mammals.

Chlordane criteria for protection of marine life (0.004 µg/L, 24-h mean; not to exceed 0.09 µg/L) seem satisfactory. Proposed criteria for freshwater life protection (0.0043 µg/L, 24-h mean; not to exceed 2.4 µg/L) however, overlap the range of 0.2 to 3.0 µg/L shown to adversely affect certain fish and aquatic invertebrates, suggesting that some downward modification in the maximum permissible level is needed. Chlordane criteria for protection of birds and mammals are inadequate because the data base is incomplete. Until these data become available, a reasonable substitute is the criteria proposed for human health protection, namely, daily intake not to exceed 0.001 mg chlordane per kilogram body weight, and diet not to exceed 0.3 mg chlordane per kilogram fresh weight.

Most authorities agree that more studies are needed in several areas: monitoring of oxychlordane concentrations in wildlife; interpretation of the biological significance of residue levels found in wildlife; standardization of analytical extraction and other techniques for quantitation of chlordane and its metabolites; reexamination of aquatic toxicity data where test concentrations exceeded the solubility of chlordane in water (6 to 9 µg/L); interaction effects with other agricultural chemicals; reevaluation of the cancer risk of chlordane on representative organisms at realistic environmental levels; effects of depleted soil fertility from chlordane induced earthworm suppression; and continuance of epidemiological studies on exposed workers.

Reference:

Eisler, R. 2000. Handbook of Chemical Risk Assessment: Health Hazards to Humans, Plants, 2 and Animals. Volume 2 – Organics. Lewis Publishers, Boca Raton, FL. ISBN 1-56670-506-1.

APPENDIX B: FIGURES

Figure 1. Des Moines TCE Site.

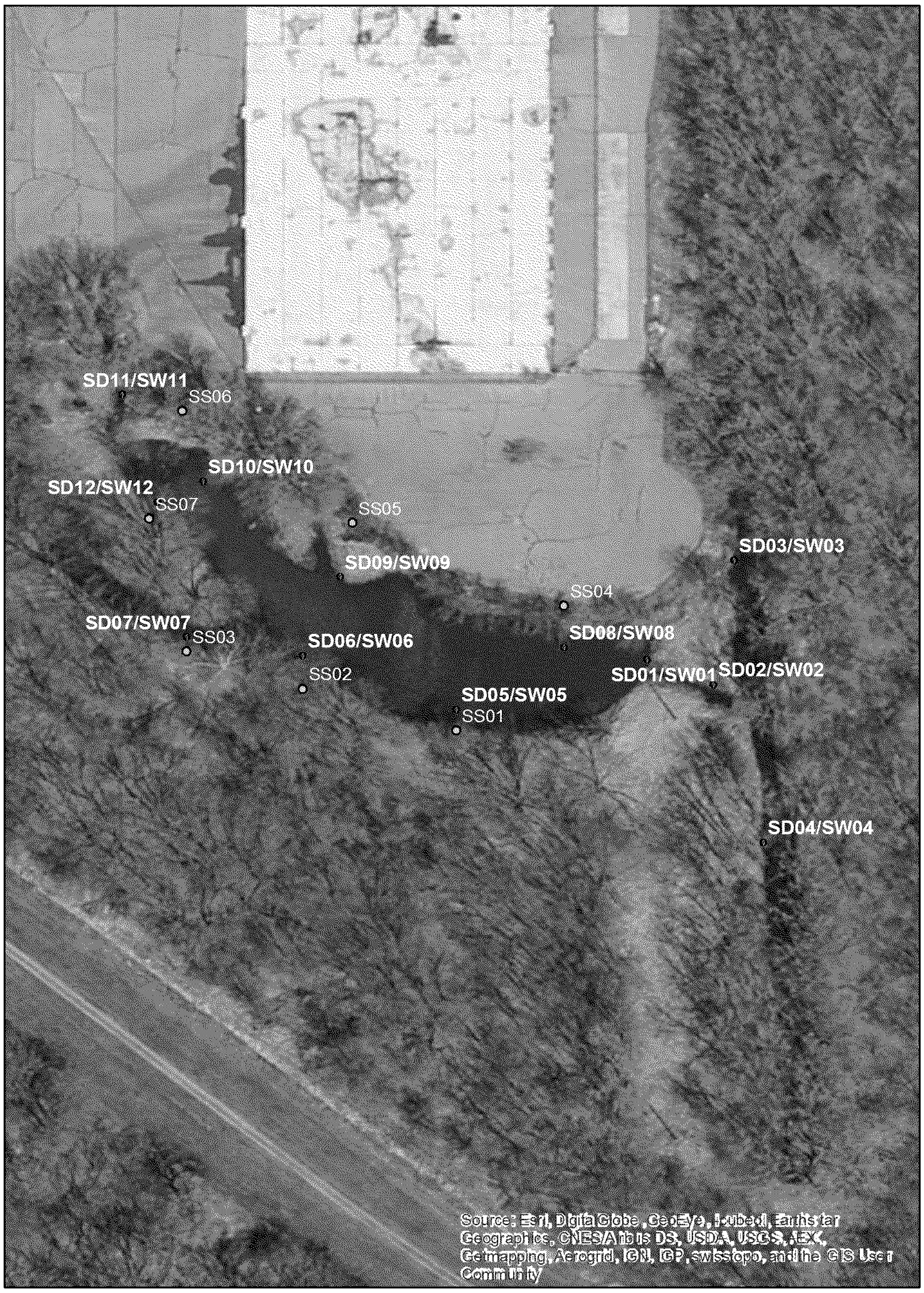
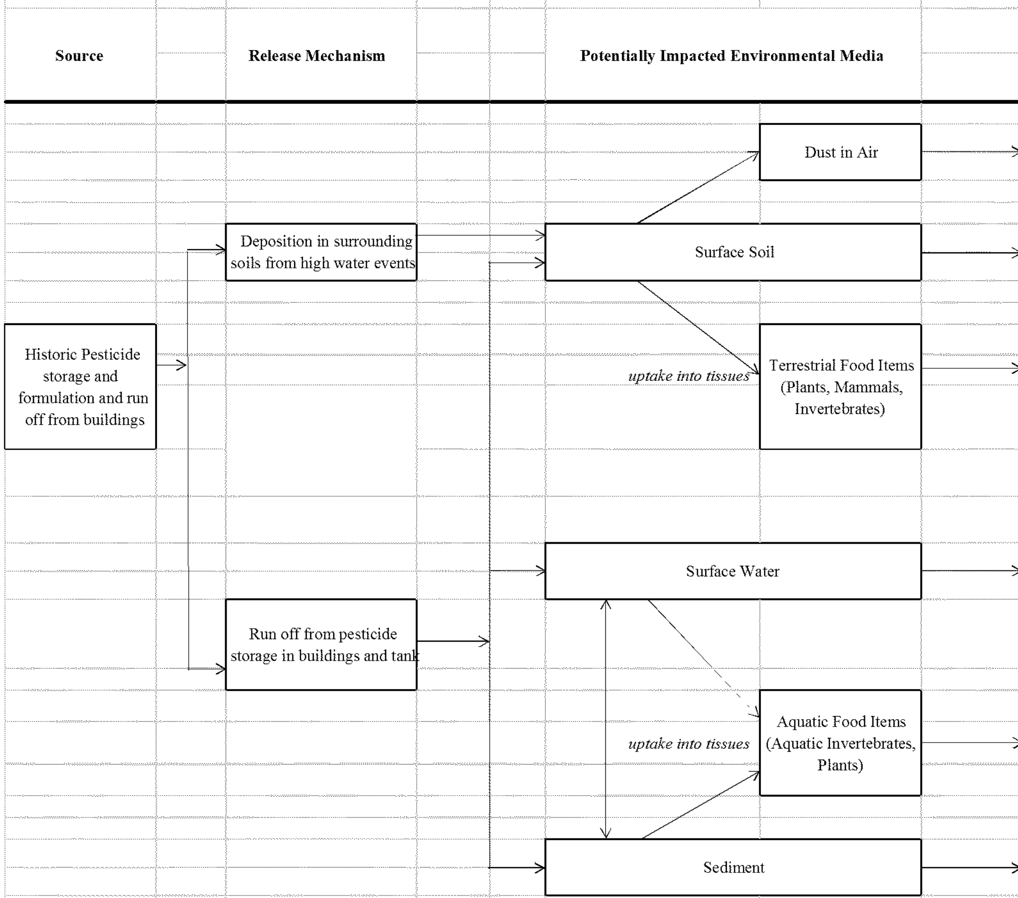


Figure 2. Sediment, Surface Water and Soil Sampling Locations.

FIGURE 3. Conceptual Model for Ecological Exposure at the Des Moines TCE Site



Potentially Impacted Environmental Media	Exposure Route	Aquatic Receptors: Amphibians	Aquatic Receptors: Benthic Organisms	Terrestrial Receptors (Plants, Invertebrates): Plants	Terrestrial Receptors (Plants, Invertebrates): Soil Organisms	Wildlife Receptors (Birds, Reptiles, Mammals)
Dust in Air	Inhalation					X
	Direct Contact			X		
Surface Soil	Ingestion				X	●
	Direct Contact			●	●	X
Terrestrial Food Items	Ingestion					●
Surface Water	Ingestion					●
	Direct Contact	●	●			X
Aquatic Food Items	Ingestion	o	o			●
Sediment	Ingestion	X	X			●
	Direct Contact	X	●			X

	Pathway is not complete, no evaluation required
X	Pathway is complete but probably cannot be evaluated quantitatively
●	Pathway is complete and could be significant, quantitative evaluation
o	Pathway is complete, limited quantitative evaluation may be possible

APPENDIX C: TABLES

Table 1. Protected Species and Species of Concern.

TYPE	SCIENTIFIC NAME	COMMON NAME	STATUS	NUMBER OF RECORDS
Fish	*Ammocrypta Clara*	Western Sand Darter	T	1
Reptile	*Emydoidea Blandingii*	Blanding's Turtle	T	3
Fish	*Esox Americanus*	Grass Pickerel	T	1
Fish	*Notropis Heterolepis*	Blacknose Shiner	T	1
Reptile	*Ophisaurus Attenuatus*	Slender Glass Lizard	T	1
Mammal	*Perognathus Flavescens*	Pocket Mouse	E	1
Butterfly	*Poanes Zabulon*	Skipper	SC	1
Mammal	*Spilogale Putorius*	Spotted Skunk	E	3
Plant	*Cirsium Hillii*	Hill's Thistle	SC	1
Plant	*Cypripedium Candidum*	Small White Lady's Slipper SC		1
Plant	*Opuntia Fragilis*	Brittle Prickly Pear	T	1
Plant	*Plantathera Praeclara*	Western Prairie Fringed Orchid	T	1
Plant	*Spiranthes Magnicamporum*	Plant Great Plains Lady's Tresses	SC	1
	Spiranthes Ovalis	Oval Lady's Tresses	T	7

E: Endangered
T: Threatened
SC: Special Concern (no protection status)
Source: Iowa Department of Natural Resources, Conservation and Recreation Division

Table 2. Assessment Endpoints and Measures of Exposure and Effects.

Assessment Endpoint	Measures of Exposure/Effects
Survival, growth and reproduction of benthic invertebrates.	Compare maximum and UCL95 concentrations of COPCs in sediment to screening benchmark values.
Survival, growth and reproduction of soil invertebrates	Compare maximum and UCL95 concentrations of COPCs in soil to screening benchmark values for soil invertebrates.
Survival, growth and reproduction of insectivorous birds and mammals	Maximum and UCL95 concentrations of COPCs measured in soil will be used in food chain models to calculate dietary exposure of selected receptor species. Calculated dietary exposure concentrations will be compared with TRVs for COPCs obtained from the literature for birds and mammals.
Survival, growth and reproduction of carnivorous birds and mammals.	Maximum and UCL95 concentrations of COPCs measured in soil will be used in food chain models to calculate dietary exposure of selected receptor species. Calculated dietary exposure concentrations will be compared with TRVs for COPCs obtained from the literature for birds and mammals.
Survival, growth and reproduction of piscivorous birds.	Maximum and UCL95 concentrations of COPCs measured in surface water will be used in food chain models to calculate dietary exposure of selected receptor species. Calculated dietary exposure concentrations will be compared with TRVs for COPCs obtained from the literature for birds.

Table 3. Exposure Point Concentrations for Sediment (µg/kg).

Location	Latitude	Longitude	TOC%	Aldrin	Detection ID	Aroclor 1016	Detection ID	Arocor 1221	Detection ID	Aroclor 1232	Detection ID
1	41.57647	-93.63753	2.88	3200	J	1200	U	1200	U	1200	U
2	41.57641	-93.63737	5.66	77	J	1700	U	1700	U	1700	U
3	41.57671	-93.63732	2.33	4200	J	780	U	780	U	780	U
4	41.57603	-93.63725	3.28	29	J	860	U	860	U	860	U
5	41.57635	-93.63799	3.09	25	UJ	850	U	850	U	850	U
6	41.57648	-93.63836	4.24	64	J	980	U	980	U	980	U
7	41.576525	-93.63864	9.05	89	J	2600	U	2600	U	2600	U
8	41.5765	-93.63773	0.366	490	J	500	U	500	U	500	U
9	41.57667	-93.63827	3.99	260	J	1000	U	1000	U	1000	U
10	41.5769	-93.6386	6.24	990	J	3400	U	3400	U	3400	U
11	41.57711	-93.63879	1.5	740	J	690	U	690	U	690	U
12	41.57685	-93.63871	5.53	110	J	1700	U	1700	U	1700	U
Maximum				4200		3400		3400		3400	
UCL95				2600							
Median											
1/2 max RL						1700		1700		1700	

Location	Latitude	Longitude	TOC %	Aroclor 1242	Detection ID	Aroclor 1248	Detection ID	Aroclor 1254	Detection ID	Aroclor 1260	Detection ID
1	41.57647	-93.63753	2.88	1200	U	1200	U	580	U	3200	U
2	41.57641	-93.63737	5.66	1700	U	1700	U	870	U	870	U
3	41.57671	-93.63732	2.33	780	U	780	U	390	U	390	U
4	41.57603	-93.63725	3.28	860	U	860	U	430	U	430	U
5	41.57635	-93.63799	3.09	850	U	850	U	420	U	420	U
6	41.57648	-93.63836	4.24	980	U	980	U	490	U	490	U
7	41.576525	-93.63864	9.05	2600	U	2600	U	1300	U	1300	U
8	41.5765	-93.63773	0.366	500	U	500	U	250	U	250	U
9	41.57667	-93.63827	3.99	1000	U	1000	U	520	U	520	U
10	41.5769	-93.6386	6.24	3400	U	3400	U	1700	U	1700	U
11	41.57711	-93.63879	1.5	690	U	690	U	340	U	1900	
12	41.57685	-93.63871	5.53	1700	U	1700	U	860	U	860	U
Maximum				3400		3400		1700		1900	
UCL95											
Median										690	
1/2 max RL				1700		1700		850			

Location	Latitude	Longitude	TOC %	A-BHC	Detection ID	B-BHC	Detection ID	D-BHC	Detection ID	G-BHC	Detection ID
1	41.57647	-93.63753	2.88	17	U	58	U	23	U	23	U
2	41.57641	-93.63737	5.66	26	U	87	U	35	U	35	U
3	41.57671	-93.63732	2.33	12	U	39	U	16	U	16	U
4	41.57603	-93.63725	3.28	13	U	43	U	17	U	17	U
5	41.57635	-93.63799	3.09	13	U	42	U	17	U	17	U
6	41.57648	-93.63836	4.24	15	U	49	U	20	U	20	U
7	41.576525	-93.63864	9.05	38	U	130	U	51	U	51	U
8	41.5765	-93.63773	0.366	7.5	U	25	U	10	U	10	U
9	41.57667	-93.63827	3.99	16	U	52	U	21	U	21	U
10	41.5769	-93.6386	6.24	51	U	68	U	100	U	68	U
11	41.57711	-93.63879	1.5	10	U	35	U	14	U	14	U
12	41.57685	-93.63871	5.53	26	U	86	U	35	U	35	U
Maximum				51		130		100		68	
UCL95											
Median											
1/2 max RL				25.5		65		50		34	

Location	Latitude	Longitude	TOC %	Chlordane	Dieldrin	Endosulfan I	Detection ID	Endosulfan II	Detection ID	Endosulfan Sulfate	Detection ID
1	41.57647	-93.63753	2.88	48000	1100	35	U	35	U	46	U
2	41.57641	-93.63737	5.66	2700	250	52	U	52	U	70	U
3	41.57671	-93.63732	2.33	32000	3200	23	U	23	U	31	U
4	41.57603	-93.63725	3.28	260	110	26	U	26	U	35	U
5	41.57635	-93.63799	3.09	500	56	25	U	25	U	34	U
6	41.57648	-93.63836	4.24	1700	53	30	U	30	U	39	U
7	41.576525	-93.63864	9.05	6200	310	77	U	77	U	100	U
8	41.5765	-93.63773	0.366	1400	450	15	U	15	U	20	U
9	41.57667	-93.63827	3.99	2500	360	31	U	31	U	42	U
10	41.5769	-93.6386	6.24	7100	1200	100	U	100	U	140	U
11	41.57711	-93.63879	1.5	5400	1100	21	U	21	U	28	U
12	41.57685	-93.63871	5.53	3500	290	52	U	52	U	69	U
Maximum				48000	3200	100		100		140	
UCL95				23829	1533						
Median											
1/2 max RL						50		50		70	

Location	Latitude	Longitude	TOC %	Endrin	Detection ID	Endrin Aldehyde	Detection ID	Endrin Ketone	Detection ID	Heptachlor	Detection ID
1	41.57647	-93.63753	2.88	46	U	58	U	46	U	35	U
2	41.57641	-93.63737	5.66	70	U	87	U	70	U	52	U
3	41.57671	-93.63732	2.33	31	U	39	U	31	U	150	
4	41.57603	-93.63725	3.28	35	U	43	U	35	U	26	U
5	41.57635	-93.63799	3.09	34	U	42	U	34	U	25	U
6	41.57648	-93.63836	4.24	39	U	49	U	39	U	30	U
7	41.576525	-93.63864	9.05	100	U	130	U	100	U	77	U
8	41.5765	-93.63773	0.366	20	U	25	U	20	U	15	U
9	41.57667	-93.63827	3.99	42	U	52	U	42	U	31	U
10	41.5769	-93.6386	6.24	140	U	170	U	140	U	100	U
11	41.57711	-93.63879	1.5	28	U	34	U	28	U	21	U
12	41.57685	-93.63871	5.53	69	U	86	U	69	U	52	U
Maximum				140		170		140		150	
UCL95											
Median										33	
1/2 max RL				70		85		70			

Location	Latitude	Longitude	TOC%	Heptachlor Epoxide	Detection ID	p,p'-DDD	Detection ID	p,p'-DDE	Detection ID	p,p'-DDT	Detection ID
1	41.57647	-93.63753	2.88	35	U	2900		190	U	61	U
2	41.57641	-93.63737	5.66	52	U	70	U	87	U	87	U
3	41.57671	-93.63732	2.33	23	U	31	U	48		39	U
4	41.57603	-93.63725	3.28	26	U	35	U	43	U	43	U
5	41.57635	-93.63799	3.09	25	U	34	U	62		42	U
6	41.57648	-93.63836	4.24	30	U	79	U	49	U	49	U
7	41.576525	-93.63864	9.05	77	U	100	U	130	U	130	U
8	41.5765	-93.63773	0.366	15	U	20	U	25	U	25	U
9	41.57667	-93.63827	3.99	31	U	86		87		52	U
10	41.5769	-93.6386	6.24	100	U	190		81		170	U
11	41.57711	-93.63879	1.5	21	U	28	U	34	U	34	U
12	41.57685	-93.63871	5.53	52	U	97	U	86	U	86	U
Maximum				100		2900		87		170	
UCL95											
Median						75		72			
1/2 max RL				50						85	

Location	Latitude	Longitude	TOC %	p,p'-Methoxychlor	Detection ID	Toxaphene	Detection ID
1	41.57647	-93.63753	2.88	120	U	1200	U
2	41.57641	-93.63737	5.66	170	U	1700	U
3	41.57671	-93.63732	2.33	78	U	780	U
4	41.57603	-93.63725	3.28	86	U	860	U
5	41.57635	-93.63799	3.09	85	U	850	U
6	41.57648	-93.63836	4.24	98	U	980	U
7	41.576525	-93.63864	9.05	260	U	2600	U
8	41.5765	-93.63773	0.366	50	U	500	U
9	41.57667	-93.63827	3.99	100	U	1000	U
10	41.5769	-93.6386	6.24	340	U	3400	U
11	41.57711	-93.63879	1.5	69	U	690	U
12	41.57685	-93.63871	5.53	170	U	1700	U
Maximum				340		3400	
UCL95							
Median							
1/2 max RL				170		1700	

Table 4. Exposure Point Concentrations for Surface Water (µg/L).

Location	Latitude	Longitude	Aldrin	Detection ID	Aroclor 1016	Detection ID	Aroclor 1221	Detection ID	Aroclor 1232	Detection ID
1	41.57647	-93.63753	0.05	U	1.0	U	1.0	U	1.0	U
2	41.57641	-93.63737	0.05	U	1.0	U	1.0	U	1.0	U
3	41.57671	-93.63732	0.05	U	1.0	U	1.0	U	1.0	U
4	41.57603	-93.63725	0.05	U	1.0	U	1.0	U	1.0	U
5	41.57635	-93.63799	0.05	U	1.0	U	1.0	U	1.0	U
6	41.57648	-93.63836	0.05	U	1.0	U	1.0	U	1.0	U
7	41.576525	-93.63864	0.05	U	1.0	U	1.0	U	1.0	U
8	41.5765	-93.63773	0.05	U	1.0	U	1.0	U	1.0	U
9	41.57667	-93.63827	0.05	U	1.0	U	1.0	U	1.0	U
10	41.5769	-93.6386	0.05	U	1.0	U	1.0	U	1.0	U
11	41.57711	-93.63879	0.05	U	1.0	U	1.0	U	1.0	U
12	41.57685	-93.63871	0.05	U	1.0	U	1.0	U	1.0	U
Maximum										
UCL95										
Median										
1/2 max RL			0.025		0.5		0.5		0.5	

Location	Latitude	Longitude	Aroclor 1242	Detection ID	Aroclor 1248	Detection ID	Aroclor 1254	Detection ID	Aroclor 1260	Detection ID
1	41.57647	-93.63753	1.0	U	1.0	U	1.0	U	1.0	U
2	41.57641	-93.63737	1.0	U	1.0	U	1.0	U	1.0	U
3	41.57671	-93.63732	1.0	U	1.0	U	1.0	U	1.0	U
4	41.57603	-93.63725	1.0	U	1.0	U	1.0	U	1.0	U
5	41.57635	-93.63799	1.0	U	1.0	U	1.0	U	1.0	U
6	41.57648	-93.63836	1.0	U	1.0	U	1.0	U	1.0	U
7	41.576525	-93.63864	1.0	U	1.0	U	1.0	U	1.0	U
8	41.5765	-93.63773	1.0	U	1.0	U	1.0	U	1.0	U
9	41.57667	-93.63827	1.0	U	1.0	U	1.0	U	1.0	U
10	41.5769	-93.6386	1.0	U	1.0	U	1.0	U	1.0	U
11	41.57711	-93.63879	1.0	U	1.0	U	1.0	U	1.0	U
12	41.57685	-93.63871	1.0	U	1.0	U	1.0	U	1.0	U
Maximum										
UCL95										
Median										
1/2 max RL			0.5		0.5		0.5		0.5	

Location	Latitude	Longitude	a-BHC	Detection ID	b-BHC	Detection ID	d-BHC	Detection ID	g-BHC	Detection ID
1	41.57647	-93.63753	0.05	U	0.05	U	0.05	U	0.05	U
2	41.57641	-93.63737	0.05	U	0.05	U	0.05	U	0.05	U
3	41.57671	-93.63732	0.05	U	0.05	U	0.05	U	0.05	U
4	41.57603	-93.63725	0.05	U	0.05	U	0.05	U	0.05	U
5	41.57635	-93.63799	0.05	U	0.05	U	0.05	U	0.05	U
6	41.57648	-93.63836	0.05	U	0.05	U	0.05	U	0.05	U
7	41.576525	-93.63864	0.05	U	0.05	U	0.05	U	0.05	U
8	41.5765	-93.63773	0.098		0.05	U	0.05	U	0.05	U
9	41.57667	-93.63827	0.05	U	0.05	U	0.05	U	0.05	U
10	41.5769	-93.6386	0.05	U	0.05	U	0.05	U	0.05	U
11	41.57711	-93.63879	0.05	U	0.05	U	0.05	U	0.05	U
12	41.57685	-93.63871	0.05	U	0.05	U	0.05	U	0.05	U
Maximum										
UCL95										
Median			0.05							
1/2 max RL					0.025		0.025		0.025	

Location	Latitude	Longitude	Chlordane	Detection ID	Dieldrin	Detection ID	Endosulfan I	Detection ID	Endosulfan II	Detection ID
1	41.57647	-93.63753	0.05	U	0.1	U	0.05	U	0.1	U
2	41.57641	-93.63737	0.05	U	0.1	U	0.05	U	0.1	U
3	41.57671	-93.63732	0.05	U	0.1	U	0.05	U	0.1	U
4	41.57603	-93.63725	0.05	U	0.1	U	0.05	U	0.1	U
5	41.57635	-93.63799	0.05	U	0.1	U	0.05	U	0.1	U
6	41.57648	-93.63836	0.05	U	0.1	U	0.05	U	0.1	U
7	41.576525	-93.63864	0.05	U	0.1	U	0.05	U	0.1	U
8	41.5765	-93.63773	0.13		0.98		0.05	U	0.1	U
9	41.57667	-93.63827	0.05	U	0.1	U	0.05	U	0.1	U
10	41.5769	-93.6386	0.05	U	0.1	U	0.05	U	0.1	U
11	41.57711	-93.63879	0.05	U	0.1		0.05	U	0.1	U
12	41.57685	-93.63871	0.05	U	0.1	U	0.05	U	0.1	U
Maximum										
UCL95										
Median			0.05		0.1					
1/2 max RL							0.025		0.05	

Location	Latitude	Longitude	Endosulfan Sulfate	Detection ID	Endrin	Detection ID	Endrin Aldehyde	Detection ID	Endrin Ketone	Detection ID
1	41.57647	-93.63753	0.1	U	0.1	U	0.1	U	0.1	U
2	41.57641	-93.63737	0.1	U	0.1	U	0.1	U	0.1	U
3	41.57671	-93.63732	0.1	U	0.1	U	0.1	U	0.1	U
4	41.57603	-93.63725	0.1	U	0.1	U	0.1	U	0.1	U
5	41.57635	-93.63799	0.1	U	0.1	U	0.1	U	0.1	U
6	41.57648	-93.63836	0.1	U	0.1	U	0.1	U	0.1	U
7	41.576525	-93.63864	0.1	U	0.1	U	0.1	U	0.1	U
8	41.5765	-93.63773	0.1	U	0.1	U	0.1	U	0.27	
9	41.57667	-93.63827	0.1	U	0.1	U	0.1	U	0.1	U
10	41.5769	-93.6386	0.1	U	0.1	U	0.1	U	0.1	U
11	41.57711	-93.63879	0.1	U	0.1	U	0.1	U	0.1	U
12	41.57685	-93.63871	0.1	U	0.1	U	0.1	U	0.1	U
Maximum										
UCL95										
Median										
1/2 max RL			0.05		0.05		0.05		0.1	

Location	Latitude	Longitude	Heptachlor	Detection ID	Heptachor Epoxide	Detection ID	p,p'-DDD	Detection ID	p,p'-DDE	Detection ID
1	41.57647	-93.63753	0.05	U	0.05	U	0.1	U	0.1	U
2	41.57641	-93.63737	0.05	U	0.05	U	0.1	U	0.1	U
3	41.57671	-93.63732	0.05	U	0.05	U	0.1	U	0.1	U
4	41.57603	-93.63725	0.05	U	0.05	U	0.1	U	0.1	U
5	41.57635	-93.63799	0.05	U	0.05	U	0.1	U	0.1	U
6	41.57648	-93.63836	0.05	U	0.05	U	0.1	U	0.1	U
7	41.576525	-93.63864	0.05	U	0.05	U	0.1	U	0.1	U
8	41.5765	-93.63773	0.05	U	0.05	U	0.1	U	0.1	U
9	41.57667	-93.63827	0.05	U	0.05	U	0.1	U	0.1	U
10	41.5769	-93.6386	0.05	U	0.05	U	0.1	U	0.1	U
11	41.57711	-93.638795	0.05	U	0.05	U	0.1	U	0.1	U
12	41.57685	-93.63871	0.05	U	0.05	U	0.1	U	0.1	U
Maximum										
UCL95										
Median										
1/2 max RL			0.025		0.025		0.05		0.05	

Location	Latitude	Longitude	p,p'-DDT	Detection ID	p,p'-Methoxychlor	Detection ID	Toxaphene	Detection ID
1	41.57647	-93.63753	0.1	U	0.5	U	5	U
2	41.57641	-93.63737	0.1	U	0.5	U	5	U
3	41.57671	-93.63732	0.1	U	0.5	U	5	U
4	41.57603	-93.63725	0.1	U	0.5	U	5	U
5	41.57635	-93.63799	0.1	U	0.5	U	5	U
6	41.57648	-93.63836	0.1	U	0.5	U	5	U
7	41.576525	-93.63864	0.1	U	0.5	U	5	U
8	41.5765	-93.63773	0.1	U	0.5	U	5	U
9	41.57667	-93.63827	0.1	U	0.5	U	5	U
10	41.5769	-93.6386	0.1	U	0.5	U	5	U
11	41.57711	-93.63879	0.1	U	0.5	U	5	U
12	41.57685	-93.63871	0.1	U	0.5	U	5	U
Maximum								
UCL95								
Median								
1/2 max RL			0.05		0.25		2.5	

Table 5. Exposure Point Concentrations for Soil (µg/kg).

Location	Latitude	Longitude	TOC %	Aldrin	Detection ID	Aroclor 1016	Detection ID	Aroclor 1221	Detection ID	Aroclor 1232	Detection ID
1	41.57630	-93.63799	4.61	19	UJ	630	U	630	U	630	U
2	41.57640	-93.63836	3.27	3.5	J	57	U	57	U	57	U
3	41.57649	-93.63864	3.21	3.6	J	59	U	59	U	59	U
4	41.57660	-93.63773	1.34	2.2	J	49	U	49	U	49	U
5	41.57680	-93.63824	4.26	16	UJ	550	U	550	U	550	U
6	41.57707	-93.63865	2.55	770	J	520	U	520	U	520	U
7	41.57681	-93.63873	7.69	120	J	700	U	700	U	700	U
Maximum				770		700		700		700	
UCL95				346.7							
Median											
1/2 max RL						350		350		350	

Location	Latitude	Longitude	TOC %	Aroclor 1242	Detection ID	Aroclor 1248	Detection ID	Aroclor 1254	Detection ID	Aroclor 1260	Detection ID
1	41.57630	-93.63799	4.61	630	U	630	U	320	U	320	U
2	41.57640	-93.63836	3.27	57	U	57	U	29	U	46	
3	41.57649	-93.63864	3.21	59	U	59	U	30	U	30	U
4	41.57660	-93.63773	1.34	49	U	49	U	25	U	38	
5	41.57680	-93.63824	4.26	550	U	550	U	270	U	270	U
6	41.57707	-93.63865	2.55	520	U	520	U	260	U	1300	
7	41.57681	-93.63873	7.69	700	U	700	U	350	U	350	U
Maximum				700		700		350		1300	
UCL95											
Median										270	
1/2 max RL				350		350		175			

Location	Latitude	Longitude	TOC %	A-BHC	Detection ID	B-BHC	Detection ID	D-BHC	Detection ID	G-BHC	Detection ID
1	41.57630	-93.63799	4.61	9.5	U	32	U	13	U	13	U
2	41.57640	-93.63836	3.27	0.86	U	2.9	U	1.1	U	1.1	U
3	41.57649	-93.63864	3.21	0.89	U	3	U	1.2	U	1.2	U
4	41.57660	-93.63773	1.34	0.74	U	2.5	U	0.98	U	0.98	U
5	41.57680	-93.63824	4.26	8.2	U	27	U	11	U	11	U
6	41.57707	-93.63865	2.55	7.8	U	26	U	10	U	10	U
7	41.57681	-93.63873	7.69	10	U	35	U	14	U	14	U
Maximum				10		35		14		14	
UCL95											
Median											
1/2 max RL				5		17.5		7		7	

Location	Latitude	Longitude	TOC %	Chlordane	Dieldrin	Detection ID	Endosulfan I	Detection ID	Endosulfan II	Detection ID
1	41.57630	-93.63799	4.61	750	750		19	U	19	U
2	41.57640	-93.63836	3.27	220	170		1.7	U	1.7	U
3	41.57649	-93.63864	3.21	290	160		1.8	U	1.8	U
4	41.57660	-93.63773	1.34	60	16	J	1.5	U	1.5	U
5	41.57680	-93.63824	4.26	150	50		16	U	16	U
6	41.57707	-93.63865	2.55	13000	15000		16	U	16	U
7	41.57681	-93.63873	7.69	8500	6200		21	U	21	U
Maximum				13000	15000		21		21	
UCL95				11963*	12530*					
Median										
1/2 max RL							10.5		10.5	

*The recommended adjusted Gamma UCL95 exceeded the maximum concentration, therefore, the 95% Chebyshev UCL was selected as the UCL95 term.

Location	Latitude	Longitude	TOC %	Endosulfan Sulfate	Detection ID	Endrin	Detection ID	Endrin Aldehyde	Detection ID	Endrin Ketone	Detection ID
1	41.57630	-93.63799	4.61	25	U	25	U	32	U	25	U
2	41.57640	-93.63836	3.27	2.3	U	2.3	U	2.9	U	2.3	U
3	41.57649	-93.63864	3.21	2.4	U	2.4	U	3	U	2.4	U
4	41.57660	-93.63773	1.34	2	U	2	U	2.5	U	2	U
5	41.57680	-93.63824	4.26	22	U	22	U	27	U	22	U
6	41.57707	-93.63865	2.55	21	U	21	U	26	U	150	
7	41.57681	-93.63873	7.69	28	U	28	U	35	U	28	U
Maximum				28		28		35		150	
UCL95											
Median										22	
1/2 max RL				14		14		17.5			

Location	Latitude	Longitude	TOC %	Heptachlor	Detection ID	Heptachlor Epoxide	Detection ID	p,p'-DDD	Detection ID	p,p'-DDE	Detection ID
1	41.57630	-93.63799	4.61	19	U	19	U	33	U	120	
2	41.57640	-93.63836	3.27	1.7	U	1.7	U	5.1	U	18	
3	41.57649	-93.63864	3.21	1.8	U	1.8	U	2.9	U	13	
4	41.57660	-93.63773	1.34	1.5	U	1.5	U	2	UJ	2.5	U
5	41.57680	-93.63824	4.26	16	U	16	U	22	U	72	
6	41.57707	-93.63865	2.55	25		83		180	U	52	
7	41.57681	-93.63873	7.69	21	U	21	U	200		140	
Maximum				25		83		200		140	
UCL95										99.9	
Median				16		16		22			
1/2 max RL											

Location	Latitude	Longitude	TOC %	p,p'-DDT	Detection ID	p,p'-Methoxychlor	Detection ID	Toxaphene	Detection ID
1	41.57630	-93.63799	4.61	69		63	U	630	U
2	41.57640	-93.63836	3.27	9		5.7	U	57	U
3	41.57649	-93.63864	3.21	9.5		5.9	U	59	U
4	41.57660	-93.63773	1.34	2.5	U	4.9	U	49	U
5	41.57680	-93.63824	4.26	64		55	U	550	U
6	41.57707	-93.63865	2.55	39	U	52	U	520	U
7	41.57681	-93.63873	7.69	61	U	70	U	700	U
Maximum				69		70		700	
UCL95				47					
Median									
1/2 max RL						35		350	

Table 6. Screening level evaluation of Assessment Endpoint #1 (aquatic macroinvertebrates).

COPC (µg/kg)	Maximum (µg/kg)	TEC (µg/kg)	ESL (µg/kg)	HQ
Aldrin	4200		2.0	>1
Aroclor 1016	3400U	60[1]		>1
Aroclor 1221	3400U	60[1]		>1
Aroclor 1232	3400U	60[1]		>1
Aroclor 1242	3400U	60[1]		>1
Aroclor 1248	3400U	60[1]		>1
Aroclor 1254	1700U	60[1]		>1
Aroclor 1260	1900	60[1]		>1
A-BHC	51U		6	>1
B-BHC	130U		5	>1
D-BHC	100U		71500	<1
G-BHC	68U	2.4		>1
Chlordane, technical	48000	3.2		>1
p,p'-DDD	2900	4.9		>1
p,p'-DDE	87	3.2		>1
p,p'-DDT	170U	4.2		>1
Dieldrin	3200	1.9		>1
Endosulfan I	100U		3.3	>1
Endosulfan II	100U		1.9	>1
Endosulfan Sulfate	140U		34.6	>1
Endrin	140U	2.2		>1
Endrin Aldehyde	170U		480	<1
Endrin Ketone	140U		NA	NA
Heptachlor	150		0.6	>1
Heptachlor Epoxide	100U	2.5		>1
p,p'-Methoxychlor	340U		13.6	>1
Toxaphene	3400U		0.077	>1

1 - TEC based on Total PCBs.

Table 7. Expanded Risk Evaluation of Assessment Endpoint #1.

COPC (µg/kg)	EPC TERM (µg/kg)			PEC (µg/kg)	HQ_{PEC}	ESB (µg/g_{oc})	ESB_{WQC} (µg/g_{oc})	ESB_{Tier2} (µg/g_{oc})	HQ_{ESB}
	UCL95	Median	½ max RL PEC						
Aldrin	2600			61.8[1]	42	49	12*		4.1
Aroclor 1016			1700	676[2]	2.5				
Aroclor 1221			1700	676[2]	2.5				
Aroclor 1232			1700	676[2]	2.5				
Aroclor 1242			1700	676[2]	2.5				
Aroclor 1248			1700	676[2]	2.5				
Aroclor 1254			850	676[2]	1.3				
Aroclor 1260			690	676[2]	1				
A-BHC			25.5	NA	NA	0.48		11	<1
B-BHC			65	NA	NA	1.22		11	<1
D-BHC			50	NA	NA	0.94		11	<1
G-BHC			34	4.99	6.8	0.64		0.37	1.7
Chlordane, technical	23829			17.6	1354				
p,p'-DDD		75		28	2.7				
p,p'-DDE		72		31.3	2.3				
p,p'-DDT			85	62.9	1.4				
Dieldrin	1533			61.8	24.8	28.9	12		2.4
Endosulfan I			50	NA	NA	0.94		0.33	2.9
Endosulfan II			50	NA	NA	0.94		1.6	<1
Endosulfan Sulfate			70	NA	NA	1.32		0.6	2.2
Endrin			70	207	<1	1.3	5.4		<1
Endrin Aldehyde			85	NA	NA				
Endrin Ketone			70	NA	NA				

Heptachlor		33		NA	NA				
Heptachlor Epoxide			50	16	3.1				
p,p'-Methoxychlor			170	NA	NA	1.6		1.9	<1
Toxaphene			1700	NA	NA	32.1		10	3.2
Total Organic Carbon	5.3								

1 - Because Aldrin is rapidly broken down to Dieldrin, the PEC and ESB for Dieldrin was used for comparison to Aldrin.
2- PEC based on Total PCBs.

Table 8. Screening level evaluation of Assessment Endpoint #2 (soil invertebrates).

COPC (µg/kg)	Maximum (µg/kg)	ESL (µg/kg)	HQ
Aldrin	770	3.32	>1
Aroclor 1016	700U	0.332	>1
Aroclor 1221	700U	0.332	>1
Aroclor 1232	700U	0.332	>1
Aroclor 1242	700U	0.332	>1
Aroclor 1248	700U	0.332	>1
Aroclor 1254	350U	0.332	>1
Aroclor 1260	1300	0.332	>1
A-BHC	10U	99.4	<1
B-BHC	35U	3.98	<1
D-BHC	14U	9940	<1
G-BHC	14U	5	>1
Chlordane, technical	13000	224	>1
p,p'-DDD	200	758	<1
p,p'-DDE	140	596	<1
p,p'-DDT	69	3.5	>1
Dieldrin	15000	2.38	>1
Endosulfan I	21U	119	<1
Endosulfan II	21U	119	<1
Endosulfan Sulfate	28U	35.8	<1
Endrin	28U	10.1	>1
Endrin Aldehyde	35U	10.5	>1
Endrin Ketone	150	NA	NA
Heptachlor	25	5.98	>1
Heptachlor Epoxide	83	152	<1
p,p'-Methoxychlor	70U	19.9	>1
Toxaphene	700U	119	>1

Table 8. Expanded Evaluation of Assessment Endpoint #2 (soil invertebrates).

COPC (µg/kg)	EPC (µg/kg)	ESL (µg/kg)	HQ
Aldrin	346.7 3.32	104	
Aroclor 1016	350U 0.332 1054		
Aroclor 1221	350U 0.332 1054		
Aroclor 1232	350U 0.332 1054		
Aroclor 1242	350U 0.332 1054		
Aroclor 1248	350U 0.332 1054		
Aroclor 1254	175U 0.332 527		
Aroclor 1260	270	0.332 813	
G-BHC	7U	5	1.4
Chlordane, technical 11963 224 53.4			
p,p'-DDT	47	3.5	13.4
Dieldrin	12530 2.38 5265		
Endrin	14U 10.1 1.4		
Endrin Aldehyde	17.5U 10.5 1.7		
Endrin Ketone	22	NA	NA
Heptachlor	16	5.98 2.7	
p,p'-Methoxychlor	35U 19.9 1.8		
Toxaphene	350U 119 3		

Table 9. Bioaccumulation Factors for Terrestrial Prey.

Pesticides/PCBs	Soil-to-Invertebrate BAF_{inv}	Animal-to-Animal BAF_{SM}	Source
Aldrin	0.56	2.9	HAZWRAP, 1994
Aroclor 1016	5.8*	2.9[1]	HAZWRAP, 1994
Aroclor 1221	5.8*	2.9[1]	HAZWRAP, 1994
Aroclor 1232	5.8*	2.9[1]	HAZWRAP, 1994
Aroclor 1242	5.8*	2.9[1]	HAZWRAP, 1994
Aroclor 1248	5.8*	2.9[1]	HAZWRAP, 1994
Aroclor 1254	5.8	2.9	HAZWRAP, 1994
Aroclor 1260	5.8	2.9[1]	HAZWRAP, 1994
A-BHC	2.6	2.9	HAZWRAP, 1994
B-BHC	2.6	2.9	HAZWRAP, 1994
D-BHC	2.6	2.9	HAZWRAP, 1994
G-BHC	2.6	2.9	HAZWRAP, 1994
Chlordane, technical	1.6	2.9	HAZWRAP, 1994
p,p'-DDD	11.2	$4.83*(11.2*C_{soil})$	USEPA, 2007
p,p'-DDE	11.2	$4.83*(11.2*C_{soil})$	USEPA, 2007
p,p'-DDT	11.2	$4.83*(11.2*C_{soil})$	USEPA, 2007
Dieldrin	14.7	$1.2*(14.7*C_{soil})$	USEPA, 2007
Endosulfan I	5.5	2.9	HAZWRAP, 1994
Endosulfan II	5.5	2.9	HAZWRAP, 1994
Endosulfan Sulfate	5.5	2.9	HAZWRAP, 1994
Endrin	1.9	2.9	HAZWRAP, 1994
Endrin Aldehyde	1.9	2.9	HAZWRAP, 1994
Endrin Ketone	1.9	2.9	HAZWRAP, 1994
Heptachlor	1.0	2.9	HAZWRAP, 1994
Heptachlor Epoxide	1.0	2.9	HAZWRAP, 1994
p,p'-Methoxychlor	0.57	2.9	HAZWRAP, 1994
Toxaphene	1.0	1.0	default

1 - Aroclor 1254 used as surrogate.

Table 10. Bioconcentratrion Factors for Small Fish.

Pesticides/PCBs	Log K_{ow}	BCF	Reference
Aldrin	3.0	3.89e+3	ECOTOX, 2015
Aroclor 1016	5.6	4.25e+4	ECOTOX, 2015
Aroclor 1221*	4.7	1.0e+05	ECOTOX, 2015 [1]
Aroclor 1232	5.1	1.0e+05	ECOTOX, 2015 [1]
Aroclor 1242	5.6	1.3e+04	ECOTOX, 2015
Aroclor 1248	6.2	6.0e+04	ECOTOX, 2015
Aroclor 1254	6.0	1.0e+05	ECOTOX, 2015
Aroclor 1260	7.1	2.7e+05	ECOTOX, 2015
A-BHC	3.8	4.5e+02	ECOTOX, 2015
B-BHC	3.8	4.5e+02	ECOTOX, 2015 [2]
D-BHC	4.1	4.5e+02	ECOTOX, 2015 [2]
G-BHC	4.1	1.8e+02	ECOTOX, 2015
Chlordane, technical	5.5	3.78e+04	ECOTOX, 2015
p,p'-DDD	6.0	8.3e+03	ECOTOX, 2015 [3]
p,p'-DDE	5.7	4.2e+04	ECOTOX, 2015
p,p'-DDT	6.4	8.3e+03	ECOTOX, 2015
Dieldrin	4.6	1.3e+04	ECOTOX, 2015
Endosulfan I	3.6	1.1e+04	ECOTOX, 2015
Endosulfan II	3.6	9.9e+03	ECOTOX, 2015
Endosulfan Sulfate	3.1	1.1e+04	ECOTOX, 2015 [4]
Endrin	5.6	0.3	ECOTOX, 2015
Endrin Aldehyde	3.1	0.3	ECOTOX, 2015[5]
Endrin Ketone	3.1	0.3	ECOTOX, 2015[5]
Heptachlor	4.3	1.7e+04	ECOTOX, 2015
Heptachlor Epoxide	5.4	1.44e+04	ECOTOX, 2015
p,p'-Methoxychlor	4.8	8.3e+03	ECOTOX, 2015
Toxaphene	5.5	4.7e+03	ECOTOX, 2015

1- Aroclor 1254 used as a surrogate.
2- a-BHC used as a surrogate
3 – DDT used as a surrogate.
4 – Endosulfan I used as a surrogate
5 – Endrin used as a surrogate.

Table 11. Estimated Concentrations in Prey.

Pesticides/PCBs	Soil Invertebrates (mg/kg)	Mammals (mg/kg)	Small Fish (mg/kg)
Aldrin	0.19	0.56	0.10
Aroclor 1016	2.03	5.89	21.25
Aroclor 1221	2.03	5.89	50
Aroclor 1232	2.03	5.89	50
Aroclor 1242	2.03	5.89	6.5
Aroclor 1248	2.03	5.89	30
Aroclor 1254	1.04	3.02	50
Aroclor 1260	1.57	4.54	135
A-BHC	0.01	0.04	0.02
B-BHC	0.05	0.13	0.01
D-BHC	0.02	0.05	0.01
G-BHC	0.02	0.05	0.05
Chlordane	19.14	55.51	1.89
p,p'-DDD	0.25	1.19	0.42
p,p'-DDE	1.12	5.41	2.10
p,p'-DDT	0.53	2.54	0.42
Dieldrin	184.2	221.03	1.3
Endosulfan I	0.06	0.18	0.55
Endosulfan II	0.06	0.18	0.5
Endosulfan Sulfate	0.08	0.22	0.55
Endrin	0.03	0.08	0.00
Endrin Aldehyde	0.03	0.1	0.00
Endrin Ketone	0.04	0.12	0.00
Heptachlor	0.02	0.05	0.43
Heptachlor Epoxide	0.02	0.05	0.36
p,p'-Methoxychlor	0.02	0.06	2.08
Toxaphene	0.35	1.02	11.75

Table 12. Average Daily Dose Equations.

Terrestrial Insectivore	IR_{biota}	IR_{soil}	C_{inv}	$C_{soil/sed}$	ADD_{biota}	Csw	IRsw	ADD_{total}	TRV_{NOAEL}	HQ	TRV_{LOAEL}	HQ
Aldrin												
Woodcock	0.214	0.164	0.19	0.35	0.0538	0.00003	0.10	0.0538	0.07	0.768	0.35	0.154
Shrew	0.209	0.030	0.20	0.35	0.0432	0.00003	0.14	0.0432	0.20	0.216	1.00	0.043
Aroclor 1016												
Woodcock	0.214	0.164	2.03	0.35	0.4467	0.00050	0.10	0.4468	0.18	2.482	1.80	0.248
Shrew	0.209	0.030	2.03	0.35	0.4265	0.00050	0.14	0.4265	1.37	0.311	3.43	0.124
Aroclor 1221												
Woodcock	0.214	0.164	2.03	0.35	0.4467	0.00050	0.10	0.4468	0.18	2.482	1.80	0.248
Shrew	0.209	0.030	2.03	0.35	0.4265	0.00050	0.14	0.4265	0.07	6.273	0.68	0.627
Aroclor 1232												
Woodcock	0.214	0.164	2.03	0.35	0.4467	0.00050	0.10	0.4468	0.18	2.482	1.80	0.248
Shrew	0.209	0.030	2.03	0.35	0.4265	0.00050	0.14	0.4265	0.07	6.273	0.68	0.627
Aroclor 1242												
Woodcock	0.214	0.164	2.03	0.35	0.4467	0.00050	0.10	0.4468	0.41	1.090	1.80	0.248
Shrew	0.209	0.030	2.03	0.35	0.4265	0.00050	0.14	0.4265	0.07	6.182	0.69	0.618
Aroclor 1248												
Woodcock	0.214	0.164	2.03	0.35	0.4467	0.00050	0.10	0.4468	0.18	2.482	1.80	0.248
Shrew	0.209	0.030	2.03	0.35	0.4265	0.00050	0.14	0.4265	0.01	42.653	0.1	4.265
Aroclor 1254												
Woodcock	0.214	0.164	1.04	0.18	0.2287	0.00050	0.10	0.2288	0.18	1.271	1.80	0.127
Shrew	0.209	0.030	1.04	0.18	0.2185	0.00050	0.14	0.2185	0.07	3.214	0.68	0.321
Aroclor 1260												
Woodcock	0.214	0.164	1.57	0.27	0.3446	0.00050	0.10	0.3446	0.18	1.915	1.80	0.191
Shrew	0.209	0.030	1.57	0.27	0.3290	0.00050	0.14	0.3291	0.07	4.839	0.68	0.484
a-BHC												

Woodcock	0.214	0.164	0.01	0.005	0.0030	0.00005	0.10	0.0030	0.56	0.005	2.25	0.001
Shrew	0.209	0.030	0.01	0.005	0.0027	0.00005	0.14	0.0028	0.01	0.197	0.14	0.020
b-BHC												
Woodcock	0.214	0.164	0.05	0.0175	0.0104	0.00003	0.10	0.0104	0.56	0.018	2.25	0.005
Shrew	0.209	0.030	0.05	0.0175	0.0096	0.00005	0.14	0.0096	0.01	0.688	0.14	0.069
d-BHC												
Woodcock	0.214	0.164	0.02	0.007	0.0041	0.00003	0.10	0.0041	0.56	0.007	2.25	0.002
Shrew	0.209	0.030	0.02	0.007	0.0038	0.00005	0.14	0.0039	0.01	0.275	0.14	0.028
g-BHC												
Woodcock	0.214	0.164	0.02	0.01	0.0041	0.00025	0.10	0.0042	2.00	0.002	20.00	0.000
Shrew	0.209	0.030	0.02	0.01	0.0038	0.00025	0.14	0.0039	8.00	0.000	NA	NA
Chlordane												
Woodcock	0.214	0.164	19.14	11.96	4.5160	0.05000	0.10	4.5210	2.14	2.113	10.70	0.423
Shrew	0.209	0.030	19.14	11.96	4.0754	0.05000	0.14	4.0824	4.60	0.887	9.20	0.444
Dieldrin												
Woodcock	0.214	0.164	184.19	12.53	39.8566	0.00010	0.10	39.8566	0.07	562.153	1.73	23.039
Shrew	0.209	0.030	184.19	12.53	38.5745	0.00010	0.14	38.5745	4.60	8.386	9.20	4.193
DDD												
Woodcock	0.214	0.164	0.25	0.02	0.0535	0.00005	0.10	0.0535	0.23	0.236	10.98	0.005
Shrew	0.209	0.030	0.25	0.02	0.0516	0.00005	0.14	0.0516	7.65	0.007	18.83	0.003
DDE												
Woodcock	0.214	0.164	1.12	0.10	0.2432	0.00005	0.10	0.2432	0.23	1.071	10.98	0.022
Shrew	0.209	0.030	1.12	0.10	0.2347	0.00005	0.14	0.2347	7.65	0.031	18.83	0.012
DDT												
Woodcock	0.214	0.164	0.53	0.05	0.1143	0.00005	0.10	0.1143	0.23	0.504	10.98	0.010
Shrew	0.209	0.030	0.53	0.05	0.1103	0.00005	0.14	0.1103	7.65	0.014	18.83	0.006
Endosulfan I												
Woodcock	0.214	0.164	0.06	0.01	0.0133	0.00005	0.10	0.0133	10.00	0.001	NA	NA
Shrew	0.209	0.030	0.06	0.01	0.0127	0.00005	0.14	0.0127	0.15	0.085	NA	NA

Endosulfan II												
Woodcock	0.214	0.164	0.06	0.01	0.0133	0.00005	0.10	0.0133	10.00	0.001	NA	NA
Shrew	0.209	0.030	0.06	0.01	0.0127	0.00005	0.14	0.0127	0.15	0.085	NA	NA
Endosulfan Sulfate												
Woodcock	0.214	0.164	0.08	0.01	0.0170	0.00005	0.10	0.0170	10.00	0.002	NA	NA
Shrew	0.209	0.030	0.08	0.01	0.0162	0.00005	0.14	0.0162	0.15	0.108	NA	NA
Endrin												
Woodcock	0.214	0.164	0.03	0.01	0.0062	0.00005	0.10	0.0062	0.01	0.619	0.10	0.062
Shrew	0.209	0.030	0.03	0.01	0.0056	0.00005	0.14	0.0057	0.09	0.061	0.92	0.006
Endrin Aldehyde												
Woodcock	0.214	0.164	0.03	0.02	0.0077	0.00005	0.10	0.0077	0.01	0.773	0.10	0.077
Shrew	0.209	0.030	0.03	0.02	0.0071	0.00005	0.14	0.0071	0.09	0.077	0.92	0.008
Endrin Ketone												
Woodcock	0.214	0.164	0.04	0.02	0.0097	0.00005	0.10	0.0097	0.01	0.972	0.10	0.097
Shrew	0.209	0.030	0.04	0.02	0.0089	0.00005	0.14	0.0089	0.09	0.097	0.92	0.010
Heptachlor												
Woodcock	0.214	0.164	0.02	0.02	0.0040	0.00003	0.10	0.0040	0.28	0.014	1.38	0.003
Shrew	0.209	0.030	0.02	0.02	0.0034	0.00003	0.14	0.0034	0.1	0.034	1	0.003
Heptachlor Epoxide												
Woodcock	0.214	0.164	0.02	0.02	0.0040	0.00003	0.10	0.0040	0.28	0.014	1.38	0.003
Shrew	0.209	0.030	0.02	0.02	0.0034	0.00003	0.14	0.0034	0.1	0.034	1	0.003
Methoxyclor												
Woodcock	0.214	0.164	0.02	0.04	0.0055	0.00025	0.10	0.0055	355.00	0.000	1775.00	0.000
Shrew	0.209	0.030	0.02	0.04	0.0044	0.00025	0.14	0.0044	4	0.001	8	0.001
Toxaphene												
Woodcock	0.214	0.164	0.35	0.35	0.0872	0.00250	0.10	0.0874	2.00	0.044	10.00	0.009
Shrew	0.209	0.030	0.35	0.35	0.0753	0.00250	0.14	0.0757	8	0.009	NA	NA

Terrestrial Carnivores	IR_{biota}	IR_{soil}	C_{inv}	C_{mam}	$C_{soil/sed}$	ADD_{biota}	Csw	IRsw	ADD_{total}	TRV_{NOAEL}	HQ	TRV_{LOAEL}	HQ
Red-tailed Hawk	0.035	0.06	0.19	0.56	0.35	0.0206	0.00003	0.05	0.0206	0.070	0.294	0.35	0.059
Long-tailed Weasel	0.130	0.04	0.19	0.56	0.35	0.0752	0.00003	0.11	0.0752	0.200	0.376	1.00	0.075
Aroclor 1016													
Red-tailed Hawk	0.035	0.06	2.03	5.89	0.35	0.2085	0.00050	0.05	0.2085	0.180	1.159	1.80	0.116
Long-tailed Weasel	0.130	0.04	2.03	5.89	0.35	0.7673	0.00050	0.11	0.7673	1.370	0.560	3.43	0.224
Aroclor 1221													
Red-tailed Hawk	0.035	0.06	2.03	5.89	0.35	0.2085	0.00050	0.05	0.2085	0.180	1.159	1.80	0.116
Long-tailed Weasel	0.130	0.04	2.03	5.89	0.35	0.7673	0.00050	0.11	0.7673	0.068	11.284	0.68	1.128
Aroclor 1232													
Red-tailed Hawk	0.035	0.06	2.03	5.89	0.35	0.2085	0.00050	0.05	0.2085	0.180	1.159	1.80	0.116
Long-tailed Weasel	0.130	0.04	2.03	5.89	0.35	0.7673	0.00050	0.11	0.7673	0.068	11.284	0.68	1.128
Aroclor 1242													
Red-tailed Hawk	0.035	0.06	2.03	5.89	0.35	0.2085	0.00050	0.05	0.2085	0.410	0.509	4.10	0.051
Long-tailed Weasel	0.130	0.04	2.03	5.89	0.35	0.7673	0.00050	0.11	0.7673	0.069	11.121	0.69	1.112
Aroclor 1248													
Red-tailed Hawk	0.035	0.06	2.03	5.89	0.35	0.2085	0.00050	0.05	0.2085	0.180	1.159	1.80	0.116
Long-tailed Weasel	0.130	0.04	2.03	5.89	0.35	0.7673	0.00050	0.11	0.7673	0.010	76.732	0.1	7.673
Aroclor 1254													
Red-tailed Hawk	0.035	0.06	1.04	3.02	0.18	0.1070	0.00050	0.05	0.1070	0.180	0.594	1.80	0.059
Long-tailed Weasel	0.130	0.04	1.04	3.02	0.18	0.3936	0.00050	0.11	0.3937	0.068	5.789	0.68	0.579

Aroclor 1260													
Red-tailed Hawk	0.035	0.06	1.57	4.54	0.27	0.1609	0.00050	0.05	0.1609	0.180	0.894	1.80	0.089
Long-tailed Weasel	0.130	0.04	1.57	4.54	0.27	0.5919	0.00050	0.11	0.5919	0.068	8.705	0.68	0.871
a-BHC													
Red-tailed Hawk	0.035	0.06	0.01	0.04	0.01	0.0013	0.00050	0.05	0.0014	0.560	0.002	2.25	0.001
Long-tailed Weasel	0.130	0.04	0.01	0.04	0.01	0.0049	0.00050	0.11	0.0050	0.014	0.356	0.14	0.036
b-BHC													
Red-tailed Hawk	0.035	0.06	0.05	0.13	0.02	0.0047	0.00003	0.05	0.0047	0.560	0.008	2.25	0.002
Long-tailed Weasel	0.130	0.04	0.05	0.13	0.02	0.0173	0.00003	0.11	0.0173	0.014	1.232	0.14	0.123
d-BHC													
Red-tailed Hawk	0.035	0.06	0.02	0.05	0.007	0.0019	0.00003	0.05	0.0019	0.560	0.003	2.25	0.001
Long-tailed Weasel	0.130	0.04	0.02	0.05	0.007	0.0069	0.00003	0.11	0.0069	0.014	0.493	0.14	0.049
g-BHC													
Red-tailed Hawk	0.035	0.06	0.02	0.05	0.007	0.0019	0.00003	0.05	0.0019	2.000	0.001	20.00	0.000
Long-tailed Weasel	0.130	0.04	0.02	0.05	0.007	0.0069	0.00005	0.11	0.0069	8.000	0.001	NA	NA
Chlordane													
Red-tailed Hawk	0.035	0.06	19.14	55.51	11.96	1.9836	0.00025	0.05	1.9836	2.140	0.927	10.70	0.185
Long-tailed Weasel	0.130	0.04	19.14	55.51	11.96	7.2832	0.00025	0.11	7.2832	4.600	1.583	9.20	0.792
Dieldrin													
Red-tailed Hawk	0.035	0.06	184.19	221.03	12.53	7.8275	0.05000	0.05	7.8300	0.071	110.438	1.73	4.526
Long-tailed Weasel	0.130	0.04	184.19	221.03	12.53	28.8038	0.05000	0.11	28.8093	0.015	1920.623	2.28	12.636
DDD													
Red-tailed Hawk	0.035	0.06	0.25	1.19	0.02	0.0421	0.00010	0.05	0.0421	0.227	0.185	10.98	0.004

Long-tailed Weasel	0.130	0.04	0.25	1.19	0.02	0.1548	0.00010	0.11	0.1548	0.147	1.053	18.83	0.008
DDE													
Red-tailed Hawk	0.035	0.06	1.12	5.41	0.10	0.1912	0.00005	0.05	0.1912	0.227	0.842	10.98	0.017
Long-tailed Weasel	0.130	0.04	1.12	5.41	0.10	0.7038	0.00005	0.11	0.7038	0.147	4.788	18.83	0.037
DDT													
Red-tailed Hawk	0.035	0.06	0.53	2.54	0.05	0.0898	0.00005	0.05	0.0898	0.227	0.396	10.98	0.008
Long-tailed Weasel	0.130	0.04	0.53	2.54	0.05	0.3308	0.00005	0.11	0.3308	0.147	2.250	18.83	0.018
Endosulfan I													
Red-tailed Hawk	0.035	0.06	0.06	0.18	0.01	0.0062	0.00005	0.05	0.0062	10.000	0.001	100.00	0.000
Long-tailed Weasel	0.130	0.04	0.06	0.18	0.01	0.0229	0.00005	0.11	0.0229	0.150	0.153	NA	NA
Endosulfan II													
Red-tailed Hawk	0.035	0.06	0.06	0.18	0.01	0.0062	0.00005	0.05	0.0062	10.000	0.001	100.00	0.000
Long-tailed Weasel	0.130	0.04	0.06	0.18	0.01	0.0229	0.00005	0.11	0.0229	0.150	0.153	NA	NA
Endosulfan Sulfate													
Red-tailed Hawk	0.035	0.06	0.08	0.22	0.01	0.0079	0.00005	0.05	0.0079	10.000	0.001	100.00	0.000
Long-tailed Weasel	0.130	0.04	0.08	0.22	0.01	0.0291	0.00005	0.11	0.0291	0.150	0.194	NA	NA
Endrin													
Red-tailed Hawk	0.035	0.06	0.03	0.08	0.01	0.0028	0.00005	0.05	0.0028	0.010	0.275	0.10	0.028
Long-tailed Weasel	0.130	0.04	0.03	0.08	0.01	0.0101	0.00005	0.11	0.0101	0.092	0.110	0.92	0.011
Endrin Aldehyde													
Red-tailed Hawk	0.035	0.06	0.03	0.10	0.02	0.0034	0.00005	0.05	0.0034	0.010	0.344	0.10	0.034
Long-tailed Weasel	0.130	0.04	0.03	0.10	0.02	0.0126	0.00005	0.11	0.0126	0.092	0.137	0.92	0.014

Endrin Ketone													
Red-tailed Hawk	0.035	0.06	0.04	0.12	0.02	0.0043	0.00005	0.05	0.0043	0.010	0.433	0.10	0.043
Long-tailed Weasel	0.130	0.04	0.04	0.12	0.02	0.0159	0.00005	0.11	0.0159	0.092	0.173	0.92	0.017
Heptachlor													
Red-tailed Hawk	0.035	0.06	0.02	0.05	0.02	0.0017	0.00005	0.05	0.0017	0.280	0.006	1.38	0.001
Long-tailed Weasel	0.130	0.04	0.02	0.05	0.02	0.0061	0.00005	0.11	0.0061	0.100	0.061	1	0.006
Heptachlor epoxide													
Red-tailed Hawk	0.035	0.06	0.02	0.05	0.02	0.0017	0.00003	0.05	0.0017	0.280	0.006	1.38	0.001
Long-tailed Weasel	0.130	0.04	0.02	0.05	0.02	0.0061	0.00003	0.11	0.0061	0.100	0.061	1	0.006
Methoxyclor													
Red-tailed Hawk	0.035	0.06	0.02	0.06	0.04	0.0021	0.00003	0.05	0.0021	355.000	0.000	1775.00	0.000
Long-tailed Weasel	0.130	0.04	0.02	0.06	0.04	0.0077	0.00003	0.11	0.0077	4.000	0.002	8	0.001
Toxaphene													
Red-tailed Hawk	0.035	0.06	0.35	1.02	0.35	0.0365	0.00025	0.05	0.0365	2.000	0.018	10.00	0.004
Long-tailed Weasel	0.130	0.04	0.35	1.02	0.35	0.1339	0.00025	0.11	0.1339	8.000	0.017	NA	NA

Avian Piscivore Heron	IR_{biota}	C_{fish}	ADD_{biota}	Csw	IRsw	ADD_{total}	TRV_{NOAEL}	HQ	TRV_{LOAEL}	HQ
Aldrin	0.18	0.10	0.0175	0.00003	0.045	0.02	0.07	0.25	0.35	0.05
Aroclor 1016	0.18	21.25	3.8250	0.00050	0.045	3.83	0.18	21.25	1.80	2.13
Aroclor 1221	0.18	50.00	9.0000	0.00050	0.045	9.00	0.18	50.00	1.80	5.00
Aroclor 1232	0.18	50.00	9.0000	0.00050	0.045	9.00	0.18	50.00	1.80	5.00
Aroclor 1242	0.18	6.50	1.1700	0.00050	0.045	1.17	0.18	6.50	1.80	0.65
Aroclor 1248	0.18	30.00	5.4000	0.00050	0.045	5.40	0.18	30.00	1.80	3.00
Aroclor 1254	0.18	50.00	9.0000	0.00050	0.045	9.00	0.18	50.00	1.80	5.00
Aroclor 1260	0.18	135.00	24.3000	0.00050	0.045	24.30	0.18	135.00	1.80	13.50
a-BHC	0.18	0.02	0.0040	0.00005	0.045	0.004	0.56	0.01	2.25	0.002
b-BHC	0.18	0.01	0.0020	0.00003	0.045	0.002	0.56	0.004	2.25	0.001
d-BHC	0.18	0.01	0.0020	0.00003	0.045	0.002	0.56	0.004	2.25	0.001
g-BHC	0.18	0.05	0.0081	0.00025	0.045	0.01	2.00	0.004	20.00	0.000
Chlordane	0.18	1.89	0.3402	0.00005	0.045	0.34	2.14	0.16	10.70	0.03
Dieldrin	0.18	1.30	0.2340	0.00010	0.045	0.23	0.07	3.30	1.73	0.14
DDD	0.18	0.42	0.0747	0.00005	0.045	0.07	0.23	0.32	10.97	0.01
DDE	0.18	2.10	0.3780	0.00005	0.045	0.38	0.23	1.64	10.97	0.03
DDT	0.18	0.42	0.0747	0.00005	0.045	0.07	0.23	0.32	10.97	0.01
Endosulfan I	0.18	0.55	0.0989	0.00005	0.045	0.099	10.00	0.01	100.00	0.00
Endosulfan II	0.18	0.50	0.0892	0.00005	0.045	0.089	10.00	0.01	100.00	0.00
Endosulfan Sulfate	0.18	0.55	0.0989	0.00005	0.045	0.099	10.00	0.01	100.00	0.00
Endrin	0.18	0.0000	0.0000	0.00005	0.045	0.00	0.01	0.00	0.10	0.00
Endrin Aldehyde	0.18	0.0000	0.0000	0.00005	0.045	0.00	0.01	0.00	0.10	0.00
Endrin Ketone	0.18	0.0000	0.0000	0.00005	0.045	0.00	0.01	0.00	0.10	0.00
Heptachlor	0.18	0.43	0.0765	0.00003	0.045	0.08	0.28	0.27	1.38	0.06

Heptachlor Epoxide	0.18	0.36	0.0648	0.00003	0.045	0.06	0.28	0.23	1.38	0.05
Methoxychlor	0.18	2.08	0.3735	0.00025	0.045	0.37	355.00	0.00	1775.00	0.00
Toxaphene	0.18	11.75	2.1150	0.00250	0.045	2.12	2.00	1.06	10.00	0.21

APPENDIX D: ProUCL RESULTS

Aldrin - Sediment

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs			
Mean	856.2	Standard Error of Mean	400
SD	1321	95% KM (BCA) UCL	1567
95% KM (t) UCL	1575	95% KM (Percentile Bootstrap) UCL	1537
95% KM (z) UCL	1514	95% KM Bootstrap t UCL	3455
90% KM Chebyshev UCL	2056	95% KM Chebyshev UCL	2600
97.5% KM Chebyshev UCL	3354	99% KM Chebyshev UCL	4837

Chlordane - Sediment

Gamma Statistics			
k hat (MLE)	0.619	k star (bias corrected MLE)	0.52
Theta hat (MLE)	14982	Theta star (bias corrected MLE)	17840
nu hat (MLE)	14.85	nu star (bias corrected)	12.47
MLE Mean (bias corrected)	9272	MLE Sd (bias corrected)	12861
		Approximate Chi Square Value (0.05)	5.54
Adjusted Level of Significance	0.029	Adjusted Chi Square Value	4.853
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50)	20874	95% Adjusted Gamma UCL (use when n<50)	23829

Dieldrin - Sediment

Gamma Statistics			
k hat (MLE)	0.885	k star (bias corrected MLE)	0.72
Theta hat (MLE)	798	Theta star (bias corrected MLE)	981.8
nu hat (MLE)	21.25	nu star (bias corrected)	17.27
MLE Mean (bias corrected)	706.6	MLE Sd (bias corrected)	832.9
		Approximate Chi Square Value (0.05)	8.867
Adjusted Level of Significance	0.029	Adjusted Chi Square Value	7.963
Assuming Gamma Distribution			
95% Approximate Gamma UCL (use when n>=50)	1376	95% Adjusted Gamma UCL (use when n<50)	1533

Total Organic Carbon - Sediment

TOC

General Statistics			
Total Number of Observations	12	Number of Distinct Observations	12
		Number of Missing Observations	0
Minimum	0.366	Mean	4.013
Maximum	9.05	Median	3.635
SD	2.346	Std. Error of Mean	0.677
Coefficient of Variation	0.584	Skewness	0.634
Normal GOF Test			
Shapiro Wilk Test Statistic	0.97	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.859	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.128	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.256	Data appear Normal at 5% Significance Level	
Data appear Normal at 5% Significance Level			
Assuming Normal Distribution			
95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	5.229	95% Adjusted-CLT UCL (Chen-1995)	5.259
		95% Modified-t UCL (Johnson-1978)	5.25

Aldrin - Soil

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs			
Mean	129.4	Standard Error of Mean	111.8
SD	264.6	95% KM (BCA) UCL	332
95% KM (t) UCL	346.7	95% KM (Percentile Bootstrap) UCL	332
95% KM (z) UCL	313.3	95% KM Bootstrap t UCL	42899
90% KM Chebyshev UCL	464.8	95% KM Chebyshev UCL	616.8
97.5% KM Chebyshev UCL	827.7	99% KM Chebyshev UCL	1242

Chlordane - Soil

Nonparametric Distribution Free UCLs			
95% CLT UCL	6557	95% Jackknife UCL	7152
95% Standard Bootstrap UCL	6348	95% Bootstrap-t UCL	67849
95% Hall's Bootstrap UCL	64849	95% Percentile Bootstrap UCL	6313
95% BCA Bootstrap UCL	6943		
90% Chebyshev(Mean, Sd) UCL	9256	95% Chebyshev(Mean, Sd) UCL	11963
97.5% Chebyshev(Mean, Sd) UCL	15719	99% Chebyshev(Mean, Sd) UCL	23098
Suggested UCL to Use			
95% Adjusted Gamma UCL	26932		
Recommended UCL exceeds the maximum observation			

Dieldrin - Soil

Nonparametric Distribution Free UCLs			
95% CLT UCL	6716	95% Jackknife UCL	7355
95% Standard Bootstrap UCL	6562	95% Bootstrap-t UCL	68438
95% Hall's Bootstrap UCL	74167	95% Percentile Bootstrap UCL	6669
95% BCA Bootstrap UCL	8205		
90% Chebyshev(Mean, Sd) UCL	9619	95% Chebyshev(Mean, Sd) UCL	12530
97.5% Chebyshev(Mean, Sd) UCL	16570	99% Chebyshev(Mean, Sd) UCL	24506
Suggested UCL to Use			
95% Adjusted Gamma UCL	32738		
Recommended UCL exceeds the maximum observation			

DDE – Soil

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs			
Mean	59.64	Standard Error of Mean	20.69
SD	49.98	95% KM (BCA) UCL	91
95% KM (t) UCL	99.85	95% KM (Percentile Bootstrap) UCL	91.71
95% KM (z) UCL	93.68	95% KM Bootstrap t UCL	113.5
90% KM Chebyshev UCL	121.7	95% KM Chebyshev UCL	149.8
97.5% KM Chebyshev UCL	188.9	99% KM Chebyshev UCL	265.5

DDT - Soil

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs			
Mean	24	Standard Error of Mean	11.84
SD	27.05	95% KM (BCA) UCL	N/A
95% KM (t) UCL	47.01	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	43.48	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	59.53	95% KM Chebyshev UCL	75.62
97.5% KM Chebyshev UCL	97.96	99% KM Chebyshev UCL	141.8

APPENDIX E: WILDLIFE EXPOSURE FACTORS

American Woodcock *(Scolopax minor)*

Food Habits and Diet Composition

Woodcocks feed primarily on invertebrates found in moist upland soils by probing the soil with their long prehensile-tipped bill (Owen et al., 1977; Sperry, 1940). Earthworms are the preferred diet, but when earthworms are not available, other soil invertebrates are consumed (Miller and Causey, 1985; Sperry, 1940; Stribling and Doerr, 1985). Some seeds and other plant matter may also be consumed (Sperry, 1940). Krohn (1970) found that during summer most feeding was done in wooded areas prior to entering fields at night, but other studies have indicated that a significant amount of food is acquired during nocturnal activities (Britt, 1971, as cited in Dunford and Owen, 1973). A diet of 100 percent earthworms was assumed (Stribling and Doerr, 1985) for the risk assessment.

Food Ingestion Rate

Stickel et al. (1965) reported a mean food ingestion rate of 0.77 g/g BW/day (range, 0.11-1.43 g/g BW/day) in captive woodcocks eating an earthworm diet during the winter in Louisiana. A normalized food ingestion rate is reported in USEPA, 2003, as 0.214 kg/kg bw/d.

Water Ingestion Rate

No literature data were found concerning water consumption rates in woodcocks. However, most of the woodcocks' metabolic water needs are reportedly met by their food (Mendall and Aldous, 1943, as cited in Cade, 1985), although captive birds have been observed to drink (Sheldon, 1967). A water consumption rate of 0.1 L/kg BW/day can be estimated (Calder and Braun, 1983) based on summer body weights from Nelson and Martin (1953).

Soil Ingestion

Soil ingestion was estimated as 0.164 as a percentage of the diet. This estimate is based on information provided in the Eco-SSL guidance (USEPA, 2005), as reported in Beyer et al. (1994).

Home Range

Home range values reported in the literature vary considerably by sex and season. Therefore, a median home range for singing males in Pennsylvania of 10.4 ha, as reported by Hudgins *et al.*, 1985, is used in the risk assessment. American woodcocks tend to be early spring migrants,leaving the wintering grounds in February and arriving in breeding territories in early March. Fall migration begins in October with the timing of the first frosts.

American Woodcock	Value	Reference
Body Weight (kg)	0.176	Nelson and Martin, 1953
Normalized Food Ingestion Rate (kg/kg bw dw/day)	0.214	Stickel et al., 1965
Water Ingestion Rate (L/kg bw/day)	0.10	Calder and Braun, 1983
Fraction Diet Earthworm	100%	Stribling and Doerr, 1985
Soil Ingestion Rate	16.4%	USEPA, 2005

Northern Short-Tailed Shrew *(Blarina brevicauda)*

Food Habits and Diet Composition
The short-tailed shrew is primarily a carnivore. Common prey items include insects, worms, snails, and other invertebrates. They may also eat mice, voles, frogs, other vertebrates and some plants and fungi (Robinson and Brodie, 1982; Hamilton, 1941). For this ERA, a simplified diet of 100 percent soil invertebrates was used in to calculate the ADD.

Food Ingestion Rate
In laboratory studies, shrews of both sexes fed a diet of mealworms had a food ingestion rate of 0.49 kg/kg bw/day (Barrett and Stuek, 1976). Lab studies using beef liver found that shrews had a food ingestion rate between 0.49 kg/kg bw/day and 0.62 kg/kg bw/day (Morrison *et al.*, 1957). USEPA (2005) estimated a food intake rate for shrews of 0.209 kg dw/kg bw/day, based on a high end point estimate. Therefore, a value of 0.209 kg dw/kg bw/day will be used to estimate exposure to the short-tailed shrew.

Water Ingestion Rate
The shrew must consume water to compensate for its high evaporative water loss, despite the fact that it obtains water from both food and metabolic oxidation (Chew, 1951). Deavers and Hudson (1981) indicated that the short-tailed shrew's evaporative water loss increases with increasing ambient temperature even within its thermoneutral zone. Therefore, a water ingestion rate of 0.223 L/kg bw/day is assumed based on a study by Chew, 1951.

Soil Ingestion Rate
Data concerning soil ingestion by short-tailed shrews was based on USEPA, 2003. A soil ingestion rate, as percentage of diet is estimated to be 0.03 mg/kg bw/d.

Home Range
Short-tailed shrews are found in a wide variety of habitats and are common in areas with abundant vegetative cover (Miller and Getz, 1977). They inhabit round, underground nests and maintain underground runaways, usually in the top 10 cm of soil, but sometimes as deep as 50 cm (Hamilton, 1931). Winter, non-breeding home ranges can vary from 0.03 to 0.07 ha at high prey densities, to 1 to 2.2 ha during low prey densities (Platt, 1976).

Short-tailed Shrew	Value	Reference
Body Weight (kg)	0.176	Nelson and Martin, 1953
Normalized Food Ingestion Rate (kg/kg bw dw/day)	0.209	Stickel et al., 1965
Water Ingestion Rate (L/kg bw/day)	0.14	Calder and Braun, 1983
Fraction Diet Earthworm	100%	Stribling and Doerr, 1985
Soil Ingestion Rate	3%	USEPA, 2005

Red-tailed Hawk (*Buteo jamaicensis*)

Food Habits and Diet Composition
Small mammals, including mice, shrews, voles, rabbits, and squirrels, are important prey, particularly during winter. Red-tails also eat a wide variety of foods depending on availability, including birds, lizards, snakes, and large insects (James, 1984; Fitch *et al.*, 1946).

Food Ingestion Rates
Food consumption rates of adult red-tailed hawks are estimated to be 0.0353 kg/kg bw/day (USEPA, 2005).

Water Ingestion Rate
No water consumption data were available for red-tailed hawks. A water consumption rate of 0.05 L/kg BW/day was calculated using the Calder and Braun (1983) equation, and a mean body weight of 1.13 kg:

$$WIR = (0.059(BW)^{0.67})/BW_{kg},$$

Soil Ingestion
No soil ingestion data were found in the literature. Soil ingestion is likely to be negligible and consist only of that associated with prey that are consumed.

Home Range
Red-tails are found in habitats ranging from woodlands, wetlands, pastures, and prairies to deserts (Bohm, 1978b; Gates, 1972; MacLaren et al., 1988; Mader, 1978). They appear to prefer a mixed landscape containing old fields, wetlands, and pastures for foraging interspersed with groves of woodlands and bluffs and streamside trees for perching and nesting (Brown and Amadon, 1968; Preston, 1990). Red-tailed hawks are territorial throughout the year, including winter (Brown and Amadon, 1968). Trees or other sites for nesting and perching are important requirements for breeding territories and can determine which habitats are used in a particular area (Preston, 1990; Rothfels and Lein, 1983). Home range size can vary from a few hundred hectares to over 1,500 hectares, depending on the habitat (Andersen and Rongstad, 1989; Petersen, 1979).

Red-tailed Hawk	Value	Reference
Body Weight (kg)	1.0	Craighead and Craighead, 1956
Normalized Food Ingestion Rate (kg/kg bw dw/day)	0.0353	USEPA, 2005
Water Ingestion Rate (L/kg bw/day)	0.05	Calder and Braun, 1983
Fraction Small Mammal	100%	Fitch *et al.*, 1948
Soil Ingestion Rate	0%	USEPA, 2005

Long-tailed Weasel (*Mustela frenata*)

Food Habits and Diet Composition
Weasels are specialist predators of small, warm-blooded vertebrates (King, 1983). Their diet consists predominantly of small mammals (50-80 percent of annual consumption) with larger species consuming larger-sized prey (Polderboer *et al*., 1941; Svendsen, 1982).

Food Ingestion Rates
Food ingestion is estimated to be 0.13 kg/kg bw/day based on USEPA, 2005.

Water Ingestion Rate
Weasels require a constant supply of drinking water, drinking small amounts frequently (Svendsen, 1982). Long-tailed weasels are reported to consume 25 mL water/d (Svendsen, 1982). No other literature data were found describing water ingestion by weasels. A water consumption rate of 0.11 L/kg BW/day was calculated using the Calder and Braun (1983) equation, and a mean body weight of 0.297 kg:

$WIR = (0.099(BW)^{0.90})/BW_{kg}$,

Soil Ingestion Rate
Soil ingestion rates are estimated to be 0.043 as a percentage of diet (USEPA, 2005).

Home Range
Home ranges of weasels vary by sex, habitat, food availability and season, with smaller species having smaller home ranges (Svendsen, 1982). Home ranges for long-tailed weasels have been reported to range from 5-16 ha in Iowa (Polderboer *et al*., 1941) to 81-121 ha in Michigan and Colorado (Quick, 1944, 1951).

Long-tailed Weasel	Value	Reference
Body Weight (kg)	0.2 – 0.34	Burt and Grossenheider, 1976
Normalized Food Ingestion Rate (kg/kg bw dw/day)	0.13	USEPA, 2005
Water Ingestion Rate (L/kg bw/day)	0.11	Calder and Braun, 1983
Fraction Small Mammal	100%	Polderboer *et al*., 1941
Soil Ingestion Rate	4.3%	USEPA, 2005

Great Blue Heron (*Ardea herodias)*

Food Habits and Diet Composition

Fish are the preferred prey, but great blue herons also eat amphibians, reptiles, crustaceans, insects, birds, and mammals (Alexander, 1977; Bent, 1926; Hoffman, 1978; Kirkpatrick, 1940; Peifer, 1979). To fish, they require shallow waters (up to 0.5 m) with a firm substrate (Short and Cooper, 1985). Fish up to about 20 cm in length were dominant in the diet of herons foraging in southwestern Lake Erie (Hoffman, 1978), and 95 percent of fish consumed by great blues in a Wisconsin population were less than 25 cm in length (Kirkpatrick, 1940). Great blue herons sometimes forage in wet meadows and pastures in pursuit of lizards, small mammals, and large insects (Palmer, 1962; Peifer, 1979).

Body Size and Weight

Body weights of adults for both sexes were reported as 2.229 kg (Quinney, 1982). Hartman (1961) reported body weights of adult females at 2.2 kg and adult males at 2.6 kg. An average adult body weight of 2.28 kg is used in the ERA.

Food Consumption Rate

There are no studies available that give specific food consumption rates. However, Kushlan (1978) developed a regression equation relating the amount of food ingested per day to body weight for wading bird:

$$\log(FI) = 0.966 \log(BW) - 0.640$$

where, FI equals food ingestion in grams per day and BW equals body weight in grams.

The food ingestion rate based on this equation is 0.18 g/g BW/day based on a body weight of 2.28 kg.

Water Ingestion Rate

No literature data were found describing water ingestion by great blue herons. A water consumption rate of 0.045 L/kg BW/day was calculated using the Calder and Braun (1983) equation, and a mean body weight of 2.28 kg:

Soil Ingestion

No information was found in the literature on soil ingestion. As a piscivorous, nonfossorial species, soil ingestion is likely to be negligible.

Home Range

Great blue herons inhabit a variety of freshwater and marine areas, including freshwater lakes and rivers, brackish marshes, lagoons, mangroves, and coastal wetlands, particularly where small fish are plentiful in shallow areas (Spendelow and Patton, 1988; Short and Cooper, 1985). Bayer (1978) reported a mean (SD) feeding territory of 0.6±0.1 ha for great blue herons feeding in freshwater marshes in Oregon.

Great Blue Heron	Value	Reference
Body Weight (kg)	2.28	Hartman, 1961
Normalized Food Ingestion Rate (kg/kg bw dw/day)	0.18	USEPA, 2005
Water Ingestion Rate (L/kg bw/day)	0.045	Calder and Braun, 1983
Fraction Small Fish	100%	Alexander, 1977
Sediment Ingestion Rate	0%	NA

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APPENDIX F: TOXICITY REFERENCE VALUES

Wildlife TRVs are derived from three primary sources, including *Toxicological Benchmarks for Wildlife: 1996 Revision* (Sample *et al.* 1996), *Ecological Soil Screening Levels for Dieldrin* (USEPA, 2007a); and *Ecological Soil Screening Levels for DDT and Metabolites* (USEPA, 2007b). When TRVs could not be identified from those sources, a literature search was conducted.

Two TRVs were identified for each wildlife receptor, including a No Observed Adverse Effect Level (NOAEL) and a Lowest Observed Adverse Effect Level (LOAEL) (Tables 1 and 2). Where Sample *et al*., (1996), or values from the literature were used to derive the TRVs, the NOAEL and LOAELs are based on the single study method. For each study, the form of the compound, test species, body weight of test species, study duration, test endpoint, exposure route, and dosage was identified. NOAEL and LOAELs were then calculated based on the dose and body weight of the test species. In cases where only a LOAEL is reported, a NOAEL can be derived by dividing the LOAEL by 10 (USEPA, 1995).

Where Eco-SSLs were used to derive TRVs (USEPA, 2007a; 2007b); the NOAEL was estimated based on the geometric means of the bounded NOAEL data for growth, reproduction and survival. However, if this value is higher than the lowest bounded LOAEL for either reproduction, growth, or survival results, the TRV is equal to the highest bounded NOAEL that is lower than the lowest bounded LOAEL for reproduction, growth, and survival. For both Dieldrin and DDT, the NOAEL was based on the highest bounded NOAEL that is lower than the lowest bounded LOAEL, not the geometric mean. The LOAEL was calculated based on the geometric mean of the bounded LOAELs for reproduction, growth, and survival. LOAELs for DDT and metabolites, and dieldrin, can be found in Table 3.

Table 1. TRVs for Mammals

COPC	Test Species	NOAEL (mg/kg/d)	LOAEL (mg/kg/d)	Reference
Aldrin	Rat	0.2	1.0	a
Aroclor 1016	Mink	1.37	3.43	a
Aroclor 1221	Oldfield Mouse	0.068	0.68	a[1]
Aroclor 1232	Oldfield Mouse	0.068	0.68	a[1]
Aroclor 1242	Mink	0.069	0.69	a
Aroclor 1248	Rhesus Monkey	0.01	0.1	a
Aroclor 1254	Oldfield Mouse	0.068	0.68	a
Aroclor 1260	Oldfield Mouse	0.068	0.68	a[1]
BHC Mixtures	Mink	0.014	0.14	a
g-BHC	Rat	8.0	NA	a
Chlordane	Mouse	4.6	9.2	a

DDT	NA	0.147	18.8	b
Dieldrin	NA	0.015	2.28	c
Endosulfan I	Rat	0.15	NA	a
Endosulfan II Rat		0.15	NA	a[2]
Endosulfan Sulfate Rat		0.15	NA	a[2]
Endrin	Mouse	0.092	0.92	a
Endrin Aldehyde Mouse		0.092	0.92	a[3]
Endrin Ketone Mouse		0.092	0.92	a[3]
Heptachlor	Mink	0.1	1.0	a
Heptachlor epoxide	Mink	0.1	1.0	a[4]
Methoxychlor Rat		4.0	8.0	a
Toxaphene	Rat	8.0	NA	a

a - Toxicological Benchmarks for Wildlife: 1996 Revision (Sample et al. 1996)
a[1] – Aroclor 1254
a[2] – Endosulfan I
a[3] - Endrin
a[4] - Heptachlor
b – Geometric means of NOAEL and LOAEL values from Ecological Soil Screening Levels for DDT and Metabolites (USEPA, 2007).
c - Geometric means of NOAEL and LOAEL values from Ecological Soil Screening Levels for Dieldrin (USEPA, 2007).

Table 2. TRVs for Birds.

COPC	Test Species	NOAEL (mg/kg/d)	LOAEL (mg/kg/d)	Reference
Aldrin	Ring Necked Pheasant 0.07		0.35	d
Aroclor 1016 Ring Necked Pheasant 0.18			1.8	a[1]
Aroclor 1221	Ring Necked Pheasant 0.18		1.8	a[1]
Aroclor 1232 Ring Necked Pheasant 0.18			1.8	a[1]
Aroclor 1242 Screech Owl		0.41	1.8	a (a[1] LOAEL)
Aroclor 1248 Ring Necked Pheasant 0.18			1.8	a
Aroclor 1254 Ring Necked Pheasant 0.18			1.8	a
Aroclor 1260 Ring Necked Pheasant 0.18			1.8	a[1]
BHC Mixtures Japanese Quail		0.56	2.25	a
g-BHC	Mallard Duck	2.0	20.0	a
Chlordane	Red-Winged Blackbird 2.14		10.7	a
DDT	NA	0.227	10.98	b
Dieldrin	NA	0.0709	1.73	c
Endosulfan I	Gray Partridge	10.0	NA	a
Endosulfan II Gray Partridge		10.0	NA	a[2]
Endosulfan Sulfate Gray Partridge		10.0	NA	a[2]
Endrin	Screech Owl	0.01	0.1	a

Endrin Aldehyde	Screech Owl	0.01	0.1	a3
Endrin Ketone	Screech Owl	0.01	0.1	a3
Heptachlor	Ring-necked Pheasant	0.28	1.38	d
Heptachlor epoxide	Ring-necked Pheasant	0.28	1.38	d
Methoxychlor	chicken	355	1775	e
Toxaphene	Black Ducks	2.0	10.0	f

a - Toxicological Benchmarks for Wildlife: 1996 Revision (Sample et al. 1996)
a1 – Aroclor 1254
a2 – Endosulfan I
a3 - Endrin
b – Geometric means of NOAEL and LOAEL values from Ecological Soil Screening Levels for DDT and Metabolites (USEPA, 2007).
c - Geometric means of NOAEL and LOAEL values from Ecological Soil Screening Levels for Dieldrin (USEPA, 2007).
d – Hill et al., 1975
e – Wiemeyer, 1996
f – Mehrle et al., 1979

Table 3. LOAEL (mg/kg bw/d) data for growth, reproduction and survival with geometric mean calculations from the Eco-SSL guidance for DDT and Dieldrin.

DDT AVIAN		DDT MAMMALS		DIELDRIN AVIAN		DIELDRIN MAMMALS	
Reproduction	0.40	Reproduction	0.27	Reproduction	0.22	Reproduction	0.03
Reproduction	0.28	Reproduction	0.69	Reproduction	0.52	Reproduction	0.72
Reproduction	0.75	Reproduction	0.74	Reproduction	0.68	Growth	1.96
Reproduction	1.13	Reproduction	1.79	Reproduction	1.70	Growth	2.00
Reproduction	1.97	Reproduction	17.10	Reproduction	1.51	Growth	1.74
Reproduction	0.49	Reproduction	19.00	Reproduction	2.60	Growth	2.05
Reproduction	1.89	Reproduction	99.00	Growth	3.78	Growth	5.22
Reproduction	5.20	Reproduction	50.00	Growth	0.52	Growth	5.22
Reproduction	6.07	Reproduction	85.30	Growth	10.10	Growth	18.00
Reproduction	21.10	Reproduction	38.80	Growth	5.93	Survival	0.23
Reproduction	32.50	Reproduction	95.60	Survival	0.18	Survival	1.33
Reproduction	46.90	Growth	4.19	Survival	3.78	Survival	0.75
Reproduction	42.50	Growth	33.70	Survival	0.54	Survival	2.00
Reproduction	29.00	Growth	96.50	Survival	0.56	Survival	3.92
Reproduction	37.50	Growth	137.00	Survival	1.25	Survival	3.96
Reproduction	51.50	Survival	5.18	Survival	1.70	Survival	1.74
Growth	2.27	Survival	24.39	Survival	2.35	Survival	2.23
Growth	2.79	Survival	25.40	Survival	2.60	Survival	3.53

Growth	2.95	Survival	81.20	Survival	4.15	Survival	5.22
Growth	42.50	Survival	69.70	Survival	4.00	Survival	24.20
Survival	1.30	Survival	137.00	Survival	4.42	Survival	18.80
Survival	4.51		Geomean 18.83	Survival	15.00		Geomean 2.28
Survival	7.54				Geomean 1.73		
Survival	5.21						
Survival	2.85						
Survival	2.93						
Survival	20.30						
Survival	22.70						
Survival	13.80						
Survival	130.00						
Survival	21.90						
Survival	25.10						
Survival	85.30						
Survival	59.40						
Survival	25.00						
Survival	43.50						
Survival	35.60						
Survival	51.50						
Survival	58.10						
Survival	132.00						
Survival	200.00						
	Geomean 10.98						

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